Biltmore Herb., no. 14, May 13, 1896 (A); White Oak Mountain, Polk County, ex Biltmore Herb., no. 14d, May 31, 1897 (A); Swain County, *T. G. Harbison*, no. 1594, May 18, 1914 (A); Swain County, *H. C. Beardslee & C. A. Kofoid*, July 7, 1891 (G, P).

ALABAMA: Huntsville, *C. S. Sargent*, Oct. 9, 1898 (A).

OKLAHOMA: Page, Le Flore County, *E. J. Palmer*, nos. 9038, 20572, 20913, 21645, Oct. 27, 1915, Sept. 23, 1921, April 25, 1922 (A).

CULTIVATED: Arnold Arboretum; Hort. Vilmorin, Verrières, France.

9. **Amorpha laevigata** Nuttall apud Torrey & Gray, Fl. N. Am. 1. 306 (1838).—Fig. 9.

Amorpha laevigata var. *typica* C. Schneider, Ill. Handb. Laubholzk. 11. 74 (1907).

A glabrous shrub 1–2.5 m. high. Leaves 1–2 dm. long; petioles slender, 2–3 cm. long; leaflets 7–21, oblong or obovate, 2–3 cm. long, 1–2 cm. wide, rounded at both ends or cuneate at base and sometimes slightly emarginate at apex, thin, conspicuously punctate beneath; petiolules conspicuously glandular. Flowering racemes usually 2 or 3 (sometimes more), slender, 1.5–3 dm. long; calyx glabrous, glandular-dotted; calyx-lobes short, the upper two rounded, the lower three lanceolate, acute; standard indigo or purple. Pod about 5 mm. long, conspicuously glandular dotted, nearly straight dorsally.

Oklahoma to Texas.—Type locality: Banks of Arkansas River near Salt River (Oklahoma).

TEXAS: Houston, Elihu Hall, no. 128, June 10, 1872 (G, N); *Lindheimer* (without locality or date) (P); *Lindheimer*, no. 38, April 1842 (G, P).[1]

I have been in some doubt as to the wisdom of maintaining the name, *A. laevigata*, Nutt., since there seems to be considerable uncertainty as to just what the plant is that was collected by Nuttall on the banks of the Arkansas River, in what is now Oklahoma. The description given in Torrey and Gray's Flora, based on his notes, seems to indicate a very distinct plant and I do not know of any from the region that quite agrees with it in all particulars. Torrey and Gray state that they had seen no specimen of it and I have been unable to find any so named by Nuttall. Since its publication the name has been applied to various glabrous or nearly glabrous

[1] A specimen in the Gray Herbarium, J. Reverchon, no. 814, on the label of which has been written in another hand: "Collected by Ball on the Neches, Van Zant County, July, 1877," and another branch on the sheet, which looks like the same collection, labelled: "Reverchon, N. W. Texas," have small, cuneate leaves, truncate to deeply emarginate at apex. It is a very curious form of *A. laevigata*, but without better material or more definite data I hesitate to describe it as a distinct variety.

forms of *Amorpha* by collectors, and the expanded descriptions of later authors seem to be based on a composite description of these.

In 1862 Buckley described *Amorpha texana* from west-central Texas, giving a clear and definite description of his type specimen, which is now preserved in the herbarium of the Philadelphia Academy of Natural Sciences. The form described by Buckley differs widely from the description of *A. laevigata*, being a plant with pubescent branches, short, few-spiked inflorescence, and broad-oblong leaflets, pubescent on under surface, rounded or emarginate at the apex and not at all narrowed at base. However, *A. texana* proved to be quite a variable species, and there is a form with leaflets glabrous or nearly so, although with pubescent calyx, which Dr. Gray identified with Nuttall's species, making it a synonym and calling the pubescent (typical) form var. *pubescens*. Specimens have also been collected in Texas which agree with *A. texana* in having the conspicuously punctate leaves and glandular calyx and petiolules which characterize the entire group, but in which the flowers are smaller, the calyx is essentially glabrous, the flowering racemes slender and elongated and the leaves sometimes narrowed at the base. This agrees fairly well with the description of *A. laevigata* as given by Torrey and Gray,[1] and it seems best to distinguish it by the older name, and to maintain Buckley's name for the commoner Texan plant, since the extreme forms differ so widely and scarcely can be brought under one specific description, although probably closely allied genetically and perhaps passing into each other.

10. **Amorpha nitens** Boynton in Biltmore Bot. Studies, I. 139 (1902).—Fig. 10.

A shrub 1–3 m. high; branches glabrous, angled. Leaves 1–2.5 dm. long, ascending; petioles 1–3 cm. long; leaflets 9–19, oblong or oblong-ovate, rounded at both ends or rarely abruptly pointed or slightly emarginate at apex, 2–6 cm. long, 1–2 cm. broad, thin, glabrous and at maturity shining above, usually thinly pubescent on the under surface, inconspicuously feather-veined (often turning black in drying). Racemes usually solitary, 0.5–2.5 dm. long, rarely with one or more additional short ones at base; rachis glabrous or

[1] *Amorpha laevigata* (Nutt. mss.): "glabrous and very smooth; leaves large; leaflets distant, elliptical oblong, attenuate below: the common petiole short; stipules minute; bracts rather long and subulate, caducous; calyx very glandular; the teeth acute, the three lower ones longer and accuminate; vexillum deep blue, about the length of the calyx; legume 1-seeded.

"Banks of the Arkansas, near Salt River,—A very distinct large shrubby remarkably smooth species, with large, distant and very obtuse leaflets, and long (8–10 inches) clustered terminal spikes. Calyx nearly glabrous except the margin, covered with elevated glands." *Nuttall.*—This species we have not seen. It is apparently allied to A. paniculata.

nearly so; calyx narrowly conic, about 3 mm. long, striate, glabrous except the ciliate margins of the lobes; calyx-lobes much shorter than the tube, the two upper ones very obtuse or rounded, the lower ones ovate, acute; standard blue-purple. Pod about 7 mm. long, curved, nearly glandless.

Georgia and Alabama to southern Illinois and in the Ozark region of Western Arkansas.—Type locality: Waynesboro, Georgia.

GEORGIA: Augusta, *T. G. Harbison*, nos. 1531, 1536, May 5, 1914 (A); Milledgeville, *Samuel Boykin* (P).

ALABAMA: Valleyhead, *T. G. Harbison*, no. 533, May 2 (A).

ILLINOIS: Golconda, Pope County, *E. J. Palmer*, nos. 15371, 23778, June 5, 1919, Sept. 17, 1923 (A).

ARKANSAS: Little Rock, Pulaski County, *E. J. Palmer*, no. 22967, May 31, 1923 (A); Gulpha, Garland County, *E. J. Palmer*, no. 24555, April 25, 1924 (A); Magnet Cove, Hot Springs County, *E. J. Palmer*, nos. 26915, 29724, April 24, 1925, April 19, 1926 (A); Hot Springs, Garland County, *E. J. Palmer*, nos. 23027, 23148, 24485, 24888, 24908, 26862, June 3, 7, 1923, April 22, May 14, 1924, April 22, 1925 (A); Wynne, Cross County, *E. J. Palmer*, no. 31662, Sept. 9, 1926 (A).

10-a. **Amorpha nitens** var. **leucodermis,** var. nov.

Amorpha leucodermis Boynton in Herb.

A typo recedit foliolis subtus pallidis vel leviter glaucescentibus et cortice pallidiore.

GEORGIA: Augusta, *F. E. Boynton*, nos. 666, 7035 (type), April 30, Sept. 3, 1902 (G).

11. **Amorpha crenulata** Rydberg in N. Am. Fl. XXIV. 30 (1919).—Fig. 11.

A shrub 1–1.5 m. high, nearly glabrous throughout. Leaves 1–2.5 dm. long, with rather remote leaflets and short (1–1.5 cm.) petioles; leaflets relatively narrow, oblong, linear-oblong or sometimes narrowly ovate or obovate in outline, 1.5–4 cm. long and 0.5–1.2 cm. wide, acute or rounded at base, obtusely pointed, truncate or slightly emarginate at apex, margins often obscurely crenulate, bright green above, paler and finely punctate-dotted beneath, firm and slightly reticulate at maturity; petiolules more or less glandular. Flowering racemes slender, one to several, rather loosely flowered below; calyx 3–4 mm. long, usually glandular, glabrous except the short ciliolate margins of the acute lobes, the lower three of which are lanceolate and about half as long as the tube; standard white. Pod 6–7 mm. long, nearly straight on the back, conspicuously glandular-dotted above the middle.

Southern Florida.—Type locality: hammocks between Cocoanut Grove and Cutler.

FLORIDA: Fort Dallas, *Dr. Cooper* (G); Miami Road, Cocoanut Grove, *Miss O. Rodham*, 1910 (A, P); near Little River, *Alfred Rehder*, no. 738, April 25, 1920 (A); near Miami, Dade County, *E. J. Palmer*, no. 27476, May 21, 1925 (A); Ft. Myer, *T. G. Harbison*, no. 12, Sept. 17, 1914 (A); between Cocoanut Grove and Cutler, *J. K. Small & J. J. Carter*, no. 718 (isotype?), Nov. 1903 (P); Miami, *H. B. Meredith*, March 14, 1917 (P); Miami, *A. P. Garber*, June–July, 1877 (G. P); Miami, *J. K. Small*, *J. J. Carter & G. K. Small*, no. 17, Feb. 1911 (P); Florida, *A. W. Chapman* (without locality or date) (P); East Florida, *Dr. Leavenworth* (P).

12. **Amorpha Curtissii** Rydberg in N. Am. Fl. XXIV. 30 (1919).—Fig. 12.

A shrub 1–3 m. high; glabrous or essentially so throughout. Leaves 1–2 dm. long; petioles 1–2 cm. long; leaflets 11–20, oblong or elliptic, 2–4 cm. long, 1–1.5 cm. wide, rounded at both ends or slightly acute at base, and sometimes at apex, dark green above, paler and punctate beneath, firm but thin at maturity. Racemes single or clustered, .5–1.5 dm. long, usually sessile or closely flowered to base; calyx glabrous except the ciliate margins of the lobes, sometimes with a few glands on upper part; calyx-lobes short, the upper two rounded, the lower three triangular and acute; standard dark bluish-purple. Pod 7–8 mm. long, 4 mm. wide, nearly straight dorsally, conspicuously glandular punctate.

North Carolina (?) to Florida.—Type locality: Jacksonville, Florida.

FLORIDA: Jacksonville, *A. H. Curtiss*, no. 4703, May 6, Aug. 21, 1894 (type) (N); Jacksonville, *A. H. Curtiss*, no. 6410, May 20, 1898 (G); vicinity of Mayport and Jacksonville, *Henry D. Keller*, 1870–76 (N); Port Orange, *F. C. Straub*, no. 166, May 2, 1895 (G, N).

SOUTH CAROLINA: Andersonville, *Louis R. Gibbes*, 1885 (N).

NORTH CAROLINA: Wilmington, ex Biltmore Herb., no. 1381L, July 1, 1904 (G).[1]

13. **Amorpha Schwerini** C. Schneider, Ill. Handb. Laubholzk. II. 69, 71 (1907).—Fig. 13.

Amorpha densiflora Boynton in Small, Fl. SE. U. S., ed. 2, 1342 (1913).

A branching shrub 1–2 m. high; branches finely pubescent. Leaves 0.5–1.5 dm. long; petioles about 1 cm. long; leaflets 11–25, oblong or ovate-oblong, 1–4 cm. long, 0.5–1.5 cm. broad, rounded at both ends, slightly emarginate at apex, dark green and short-

[1] The fruit in this specimen is 9–10 mm. long and distinctly curved. In other characters it appears to agree with description of this species.

pilose above, paler and densely soft-pubescent beneath. Calyx 4–6 mm. long, pilose, the lobes all lanceolate, subulate, as long or longer than the tube; standard purple. Pod about 5 mm. long, straight dorsally, punctate and puberulent.

North Carolina and Georgia.—Type locality: Dunn's Mountain, Roan County.

North Carolina: Dunn's Mountain, *J. K. Small*, Aug. 18–27, 1894 (isotype) (N); Crowder's Mountain, ex Biltmore Herb., nos. 14764, 14765b, Sept. 26, 1902, May 14, 1904 (N).

Georgia: Augusta, *C. S. Sargent*, April 29, 1914 (A).

14. **Amorpha paniculata** Torrey & Gray, Fl. N. Am. 1. 306 (1838). —Fig. 14.

Amorpha Roemeriana Scheele in Linnaea, xxi. 461 (1848).

A stout shrub 2–3 m. tall, growing in sandy bogs or wet ground; branchlets sulcate, tomentose. Leaves 2–3.5 dm. long; petioles 4–5 cm. long; leaflets 15–19, oval or oblong, 3–8 cm. long, 1.5–3 cm. wide, rounded at both ends or rarely emarginate at apex, when young finely short-pilose above and densely tomentose beneath, at maturity glabrous and glossy above and still tomentose on lower surface, prominently feather-veined. Calyx oblique, narrow-campanulate, pubescent, the lobes lanceolate, about half as long as the tube; standard purple. Pod 6–8 mm. long, more or less curved dorsally, pubescent and with large resinous glandular dots.

Louisiana and southwestern Arkansas to southern Oklahoma and eastern Texas.—Type locality: Arkansas.

Arkansas: Fulton, *B. F. Bush*, no. 5818, June 10, 1909 (A); McNab, Hempstead County, *E. J. Palmer*, no. 22310, Oct. 12, 1922 (A).

Louisiana: Lecompte, *R. S. Cocks*, no. 116, April, 1901 (A).

Texas: *F. Lindheimer*, no. 37, 1843 (without locality) (G, P); *Drummond expedition*, no. 461 (without locality or date) (A, P); neighborhood Zavala, *Dr. Leavenworth*, July (P); *Wright*, (without locality or date) (G); *Lindheimer*, Brazos, July, 1843 (P); Headwater, *J. Reverchon*, no. 2665, June 18, 1901 (A); Marshall, *B. F. Bush*, no. 991, Oct. 8, 1901 (A); Marshall, Harrison County, *E. J. Palmer*, no. 8635, Sept. 24, 1915 (A); Big Sandy, Upshur County, *E. J. Palmer*, no. 31728, Sept. 27, 1926 (A); Grapeland, Houston County, *E. J. Palmer*, nos. 12829, 14414, Sept. 22, 1917, Sept. 16, 1918 (A).

Cultivated: Arnold Arboretum.

15. **Amorpha texana** Buckley in Proc. Acad. Nat. Sci. Phila. 1861, p. 452 (1862).[1]—Fig. 15.

[1] The original description of this species is as follows:
Amorpha T e x a n a, s. nov.—Fruticosa, foliis magnis, foliolis 4–6-jugis, elliptico-

Amorpha laevigata var. *pubescens* Gray, Pl. Wright. 1. 49 (1852).
Amorpha texana var. *mollis* Boynton in Biltmore Bot. Studies, 1. 149 (1902).
Amorpha subglabra Heller, Bot. Exped. to Texas, 48 (1925).[1]

A shrub 1–3 m. high, with spreading branches; branches, foliage and inflorescence more or less pubescent. Leaves 1–1.5 dm. long; petioles 1–2 cm. long; leaflets 7–15, broad-oblong or oval, 1.5–4 cm. long, 1.5–3 cm. wide, rounded at both ends or emarginate at apex, sometimes deeply so, firm, dark green and glossy above, paler and pubescent at least along the veins beneath; petiolules 3–5 mm. long, usually pubescent and conspicuously glandular. Flowering racemes single or few, 0.5–1.5 dm. long, rather loosely flowered, at least near the base; rachis pubescent; calyx narrow-campanulate, 4–5 mm. long, more or less pilose-pubescent, glandular; calyx-lobes all much shorter than the tube, the two upper blunt or round, the three lower short-lanceolate, acute; standard blue or violet. Pod 6–7 mm. long, nearly straight dorsally, conspicuously glandular-dotted.

Central and southwestern Texas.—Type locality: on the Pedernales River. Usually found on banks and along beds or rocky streams in the limestone regions.

TEXAS: Dead Man's Hole, on the Pedernales River, *S. B. Buckley* (type), June, 1861 (P); Kerr County, *A. A. Heller*, no. 1772, May 14–21, June 19–26, 1894 (A, G, P); Kerrville, Kerr County, *E. J. Palmer*, nos. 13623, 33826, May 16, 1918, May 7, 1928 (A); Lacey's Ranch, Kerr County, *E. J. Palmer*, no. 10028, June 2, 1918 (A); Spanish Pass, Kendall County, *E. J. Palmer*, no. 9862, May 23, 1916 (A); Fischer's Store, Comal County, *E. J. Palmer*, no. 12193, June 6, 1917 (A); Texas, *Charles Wright*, 1849 (G); Fredericksburg, *F. Lindheimer*, no. 16, June, 1847 (G).

15a. **Amorpha texana** var. **glabrescens,** var. nov.

Amorpha fruticosa var. (1) Gray in Boston Jour. Nat. Hist. VI. (1850).

A typo recedit foliolis glabris vel subglabris.

Central and southwestern Texas.

oblongatis emarginatis mucronatis basi obtusis, breve petiolatis, subtus glanduloso-pubescentibus supra glabris, spicis axillaribus vel capitatis glanduloso-tomentosis, folio parum longioribus, sublaxifloris, floribus breve pedicellatis, calycis dentibus, subaequalibus, ovatis, acutis, stylo exserto villoso, leguminibus subovatis, arcuatis, acutis.

On the Pierdenalis [*sic*] River. June.

Shrub 4–5 ft. high. Racemes and flowers brownish-red; filaments and style long, exserted; leaflets 1–2 inches long and ¾–1¼ wide, the pairs at intervals of about an inch from each other; corolla more than twice the length of the calyx; flowers large in comparison with other species.

[1] Heller's plant, judging by the sheets I have seen of it, appears to be typical *Amorpha texana*, and not the subglabrous plant referred to as a variety of *A. fruticosa* by Gray in Plantae Lindheimerianae, with which he seems to have identified it. For this reason I am using another name for the form of *A. texana* with glabrous leaflets.

TEXAS: New Braunfels, *F. Lindheimer*, no. 743 (type), May, 1850 (A); *Lindheimer*, ex G. W. Short Herb., no. 296, 1849–50 (G, P); Bandera, *J. Reverchon*, no. 1513, June, 1885 (A); Headwaters of the Medina, *J. Reverchon*, no. 42, 1885 (G); Medina Lake, Bandera County, *E. J. Palmer*, no. 12259, June 14, 1917 (A).

16. **Amorpha virgata** Small in Bull. Torrey Bot. Club, XXI. 17 (1894).—Fig. 16.

An erect shrub 1–2 m. high, with single or several stems, usually branching at the summit; branches finely canescent or short pilose when young, becoming glabrous. Leaves 1–2 dm. long; petioles 1.5–2.5 cm. long; leaflets 9–19, oblong or oblong-ovate, often twice as long as wide, 2–5 cm. long, 1–2.5 cm. wide, rounded at both ends or sometimes slightly emarginate at the scarcely mucronate apex; petiolules slender, 3–4 mm. long. Inflorescence usually of several clustered, erect spikes, 1–2 dm. long; standard blue or blue-purple; calyx sparingly villous or canescent at flowering time, glabrous at maturity except the ciliate margins of the lobes; calyx-lobes all much shorter than tube, the two upper obtuse or rounded, the lower triangular and acute. Pod 6–7 mm. long, slightly curved or nearly straight dorsally, usually distinctly keeled, much flattened, glabrous and with rather remote glandular dots.

Florida to Alabama, northward in the Mississippi Valley to southern Illinois, and in the Ozark region of western Arkansas and eastern Oklahoma.—Type locality: Stone Mountain, De Kalb County, Georgia.

FLORIDA: Eustis, *Geo. V. Nash*, no. 261, March 12–31, 1894 (A, G) and no. 1137, July 1–15, 1894 (G, P); Eustis, *T. G. Harbison*, no. 10, June 22, 1919 (A); Sumner, *T. G. Harbison*, no. 8, June 12, 1915 (A); Lake Bersford, Volusia County, *A. H. Curtiss*, no. 6684, July 11, 1900 (G, P); Myers, *A. S. Hitchcock*, no. 52, July-Aug., 1900 (G).

GEORGIA: Stone Mountain, DeKalb County, *J. K. Small*, July 3, 17, 1893 (isotypes) (A, G, P); Stone Mountain, ex Biltmore Herb., no. 14c, May 12, Sept. 8, 1897 (A, G); Stone Mountain, *C. R. Pollard & Wm. R. Maxon*, no. 464, Aug. 10, 1900 (G); McGuire Mill, Gwinnett County, *J. K. Small*, July 17, 1893 (G); "in montibus carolinae et Georgiae," *S. B. Buckley* (P).

ALABAMA: summit of Cheawhan Mountains, Clay County, *Chas. Mohr*, July 31, 1896 (A).

MISSISSIPPI: Byram, *T. G. Harbison*, no. 6, May 24, 1915 (A); West Point, *T. G. Harbison*, no. 7, May 4, 1914 (A); Jackson, *T. G. Harbison*, nos. 59, 61, April 17, 1915 (A).

ARKANSAS: top of Magazine Mountain, Logan County, *E. J. Palmer*, no. 24187, Oct. 17, 1923 (A); Magnet Cove, Hot Springs County, *E. J. Palmer*, no. 26591, Oct. 15, 1924 (A); Hot Springs, Garland County, *E. J. Palmer*, no. 24252, Oct. 20, 1923 (A).

OKLAHOMA: Beachton, McCurtain County, *E. L. Little, Jr. & C. E. Olmstead*, no. 510, July 3, 1930 (A).

CULTIVATED: Arnold Arboretum.

17. **Amorpha croceolanata** Watson, Dendr. II. pl. 139 (1825).—Fig. 17.

Amorpha fruticosa var. b. *croceolanata* C. Schneider, Ill. Handb. Laubholzk. II. 73 (1907).

A stout shrub 2–3 m. high; branchlets furrowed or striate, more or less villous-pubescent, usually copiously so on young growth. Leaves 1.5–2.5 dm. long; petioles 1.5–3 cm. long; leaflets 13–23, oblong or ovate-oblong, 2.5–6 cm. long, 1.5–2.5 cm. broad, rounded at both ends or sometimes slightly cordate at base or emarginate at apex, conduplicate as they unfold and then densely covered with tawny, matted, tomentum, firm but thin at maturity, sparsely villous above and copiously so on lower surface, at least along the veins and on the petiolules. Inflorescence of from one to several erect spikes 1–1.5 dm. long; calyx more or less villous-pubescent, usually copiously so, the lobes all much shorter than the tube, the upper two broadly triangular or rounded, the lower slightly longer and more acute; standard purple blue. Pod 6–7 mm. long, curved dorsally, punctate-dotted and usually pubescent, at least when young.

Florida to Louisiana and northward in the Mississippi valley to southern Illinois and Missouri, and in the southern part of the Ozark region of southern and western Arkansas. Swamps and rocky banks of streams in the coastal plain or piedmont regions.

FLORIDA: Duval County, *A. Fredholm*, no. 5165, May 5, 1902 (A, G); South Jacksonville, Duval County, *J. R. Churchill*, April 13, 1897 (G); Lake County, *Thomas Holm*, March 12, 1893 (G); Duval County, *A. H. Curtiss*, no. 572, April (G, P); St. Marks, *T. G. Harbison*, no. 1505, April 29, 1914 (A); Old Town, Lafayette County, *E. J. Palmer*, no. 27311, May 16, 1925 (A); Bradford, Suwannee County, *R. M. Harper*, no. 155, April 17, 1910 (A, P); Hastings, *Alfred Rehder*, no. 702, April 19, 1920 (A); Florida, *A. W. Chapman* (without locality or date) (G, P).

GEORGIA: Augusta, *C. S. Sargent*, April 6, 1914 (A); Augusta, *T. G. Harbison*, no. 1522, May 4, 1914 (A); Milledgeville, *T. G. Harbison*, no. 1556, May 6, 1914 (A).

ALABAMA: Mobile (without name of collector), Oct. 25, 1839 (G);

Mobile, *Bigelow* (G); Alabama, *Buckley* (without locality or date) (G); Alabama (without name of collector or locality), 1849 (G); Selma, *T. G. Harbison*, no. 577, May 11 (A); Sardis, *T. G. Harbison*, no. 1465, April 23, 1914 (A); Tuscaloosa County, *E. J. Palmer*, no. 35380, April 15, 1929 (A); Demopolis, Marengo County, *E. J. Palmer*, no. 27200, May 14, 1925 (A).

MISSISSIPPI: Ocean Springs, *Josephine Skehan*, no. 42, April 1892 (G), and May 8, 1895 (A, G); Tishomingo County, *T. G. Harbison*, no. 21, May 5, 1913 (A).

LOUISIANA: Chopin, Natchitoches Parish, *E. J. Palmer*, no. 7548, May 6, 1915 (A).

KENTUCKY: Paducah, McCracken County, *E. J. Palmer*, nos. 17929, 22498, 27341, June 17, 1920, May 3, Sept. 15, 1923 (A).

MISSOURI: Malden, Dunklin County, *E. J. Palmer*, no. 30317, May 25, 1926 (A).

ARKANSAS: Faulkner County, *J. T. Buchholz*, no. 948, May 30, 1924 (A); Magnet Cove, Hot Springs County, *E. J. Palmer*, no. 26918, April 24, 1925 (A); Hot Springs, Garland County, *E. J. Palmer*, nos. 23051, 24517, 24909, 26863, June 4, 1923, April 24, May 14, 1924, April 22, 1925 (A): High Point, Garland County, *E. J. Palmer*, no. 24943, May 15, 1924 (A).

CULTIVATED: Arnold Arboretum and in other American and European gardens.

18. **Amorpha Bushii** Rydberg in N. Am. Fl. XXIV. 31 (1919).—Fig. 18.

A shrub 1–2 m. high; branches sparsely pilose when young, becoming glabrous. Leaves 2–3 dm. long; petioles 3–4 cm. long; leaflets 11–25, oblong, lance-oblong or ovate-oblong, 2–5 cm. long, 1–2 cm. wide, rounded at both ends, or rarely contracted at base or emarginate at apex, remote or at least not crowded on rachis, dark green, dull and glabrous or sparsely short-pilose above, paler and softly pilose beneath. Flowering racemes slender, 1–2 dm. long, usually two or three in cluster; calyx about 4 mm. long, sparingly pilose or nearly glabrous, except the margins of the very short lobes, the upper two of which are rounded or almost obsolete and the three lower short triangular and acutish; standard purple. Pod 6–7 mm. long, straight dorsally, glabrous and sparingly glandular-dotted.

Florida to Louisiana.—Type locality: near Chattahoochee River, Florida.

FLORIDA: near Chattahoochee River, *B. F. Bush*, no. 13 (isotype), Aug. 12, 1897 (A); Chattahoochee River, Gadsden County, *E. J. Palmer*, no. 35263, April 10, 1929 (A); Marianna, Jackson County,

E. J. Palmer, no. 35302, April 12, 1929 (A); Florida, *A. W. Chapman* (without locality or date) (P).

LOUISIANA: Alexandria, *Josiah Hale* (P); Louisiana, *Wm. Carpenter* (without locality or date) (P); Mississippi delta, Panther basin, *Chas. Mohr*, May, 1894 (A).

19. **Amorpha occidentalis** Abrams in Bull. N. Y. Bot. Gard. VI. 394 (1910).—Fig. 19.

A shrub 2–3 m. high; branches and foliage more or less pubescent with short appressed hairs. Leaves 1–2 dm. long; petioles 2–3 cm. long; leaflets 11–27, oblong or elliptic, rounded or abruptly narrowed at base, rounded or rarely abruptly pointed at apex, 1.5–3 cm. long, 0.75–1.5 cm. wide, firm but thin at maturity, dark green and slightly reticulately veined above, paler and sparingly black dotted and more or less pilose, at least along veins beneath, not crowded on rachis. Flowering racemes usually single, slender, 1.5–2.5 dm. long, peduncled, sometimes with one or more additional shorter ones at base; calyx 3–4 mm. long, nearly glabrous or slightly pilose on tube; calyx-lobes all much shorter than the tube, the upper two broad and obtuse, the lower three triangular, acute, villous or ciliate along the margins; standard dark blue. Pod 6–7 mm. long, slightly curved dorsally, glabrous and conspicuously glandular-dotted.

Wyoming and western Texas to Arizona, California and northern Mexico.—Type locality: San Diego River, near Old Mission, California.

CALIFORNIA: Torrey Pines Park, San Diego County, *Philip A. Munz*, no. 1953, May 9, 1924 (G); Pipe Creek, Hemet Valley, San Jacinto Mts., *Mary F. Spencer*, no. 2191, Aug. 17, 1923 (G); San Diego County, *Edward Palmer*, no. 65, 1875 (G); San Diego River, near Old Mission, *LeRoy Abrams*, no. 3425 (isotype), May 6, 1903 (A, G, P); Wilson Creek, San Diego County, *LeRoy Abrams*, no. 4917, July 11, 1912 (A); San Diego, *C. S. Sargent*, Sept. 18, 1894 (A); San Bernardino, *S. B. & W. F. Parish*, no. 147, April 1881 (A); Waterman Cañon, San Bernardino Mts., *S. B. Parish*, no. 11379, June 14, 1917 (A); Cuyamaca, San Diego County, *Alice Eastwood*, no. 9139, June 25, 1919 (A); Coachella, Riverside County, *Philip A. Munz*, no. 10841, May 2, 1927 (A); San Jacinto Mts., *H. M. Hall*, no. 2121, June, 1901 (P).

WYOMING: Platte Cañon, Laramie County, *Aven Nelson*, no. 8651, Sept., 1901 (G).

TEXAS: Boerne, *S. H. Hastings*, 1911 (A); vicinity of El Paso, *Elmer Stearns*, no. 116, 1911 (A); New Braunfels, *H. A. Pilsbry*,

April 17–19, 1903 (P); Tarrent Co., *Albert Ruth*, no. 21, May 5, 1919 (P).

New Mexico: Tierra Blanca, *Mrs. I. M. Beals*, 1904 (G); Kingston, *O. B. Metcalf*, no. 930, May 24, 1904 (A); Cliff, Grant County, *O. B. Metcalf*, no. 133, June 13, 1903 (G); Upper Gila River, *E. L. Greene*, no. 126, May 27, 1880 (G); Albuquerque, Bernalillo County, *E. J. Palmer*, no. 31129, June 20, 1926 (A).

Arizona: San Pedro Valley, *L. N. Gooding*, no. 53a, April, 1908 (G); Summit Ranch, Lectanes Plateau, *L. N. Gooding*, no. 705, July 28, 1910 (G); Willow Springs, *J. T. Rothrock*, no. 244, 1874 (G); Stephens Ranch, *Miss Bettina Stephens*, June 24, 1907 (G); Bonito Cañon, *J. S. Blummer*, no. 1292, Aug. 19, 1906 (G); Santa Catalina Mts., *Alfred Rehder*, no. 261, Aug. 1914 (A); Cave Creek Cañon, Chiricahua Mts., *J. W. Toomey*, July, 1894 (A); Santa Rita Mts., *C. G. Pringle*, May 5, 1881 (P); Arizona (without locality), *C. G. Pringle*, June 5, 1884 (P).

Mexico: Sonora, *Geo. Thurber*, no. 351, June 1851 (G).

19a. **Amorpha occidentalis** var. **emarginata,** var. nov.—Fig. 19a.

A typo recedit foliolis brevioribus apice truncatis vel retusis, glabratis vel subglabratis.

Arizona and southern California.—Type locality: Fish Creek, Apache Trail, Arizona.

California: Banning, San Diego County, *F. G. Woodcock*, no. 1628, April, 1922 (A); San Diego, *Mary F. Spencer*, no. 1442, April 25, 1926 (G).

Arizona: Fish Creek, Apache Trail (Cochise Co.?), *Alice Eastwood*, no. 8745, May 19, 1919 (type) (A); road to Pleasant Valley, Sierra Hucha, *Susan D. McKelvey*, no. 1183, May 30, 1929 (A).

19b. **Amorpha occidentalis** var. **arizonica,** comb. nov.—Fig. 19b.

Amorpha arizonica Rydberg in N. Am. Fl. xxiv. 33 (1919).

Differs from the type only in the looser and more copious pubescence of the branches, foliage and inflorescence.

Arizona and New Mexico.—Type locality of *Amorpha arizonica* Rydb.: Ramsey Cañon, Huachuca Mts., Arizona.

Arizona: Ramsey Cañon, Huachuca Mts., *L. N. Gooding*, no. 136 (isotype), June 10, 1909 (G).

20. **Amorpha fruticosa** Linnaeus, Spec. Pl. 713 (1753).—Fig. 20.

Amorpha perforata Schkuhr, Handb. ii. 333 (1796).
Amorpha nonperforata Schkuhr, l. c.
?Amorpha arborea Hort. ex Schkuhr, l. c.; nomen nudum.
Amorpha fruticosa α. vulgaris Pursh, Fl. Am. Sept. ii. 466 (1814).
?Amorpha elata Hayne, Dendr. Fl. 134 (1822).
Amorpha ornata Wenderoth, Ind. Sem. Hort. Marb. (1838); nomen nudum.

?Amorpha herbacea Schlechtendal, Ind. Sem. Hort. Hal. 8 (1848), nomen nudum.—Not *A. herbacea* Walt.

Amorpha pubescens Schlechtendal in Linnaea, XXIV. 691 (1851).—Not *A. pubescens* Willd.

Amorpha Ludvigii Hort. ex K. Koch, Dendr. I. 70 (1869), nomen nudum.

Amorpha fruticosa var. a *typica* C. Schneider, Ill. Handb. Laubholzk. II. 72 (1907).

A shrub 2–4 m. high, or rarely higher; branches striate, more or less strigose or pilose. Leaves 0.7–2 dm. long, usually ascending; petioles 1–2 cm. long; leaflets 9–25, oblong, elliptic or slightly ovate, rounded or abruptly pointed at both ends, or in forms sometimes cuneate at base, or emarginate at apex, usually finely pubescent above and more or less densely villous beneath when young, at maturity dull green and glabrous above, slightly paler and still pubescent, at least along the veins, beneath; petiolules 2–3 mm. long. Inflorescence usually of several clustered, erect, closely-flowered spikes 1–1.5 dm. long; calyx sparingly pilose, becoming glabrous in age except the ciliate margins of the lobes; calyx-lobes all much shorter than the tube, the two upper ones very blunt or rounded, the lower ones acute; standard purplish-blue, varying to pale blue or white in forms. Pod 7–8 mm. long, more or less curved dorsally, glabrous and marked by large resinous dots.

? Connecticut to Alabama and westward to Minnesota and Oklahoma.

Naturalized in the northeastern states and also in Europe and western Asia.

In cultivation since the eighteenth century and passing into several more or less distinct varieties and a number of forms, which have been distinguished in horticulture and in a wild state.

MASSACHUSETTS (introduced): vicinity of Woods Hole, *John M. Fogg, Jr.*, June 25, 1923 (P); Mystic Pond, Arlington, *C. K. Knowlton*, June 18, 1898 (G); Boston, Back Bay, *F. E. Williams*, Sept. 17, 1910 (G); Boston, Fenway, *Arthur Stanley Pease*, no. 9831, Oct. 9, 1906 (G).

NEW HAMPSHIRE (introduced): Lake Winnepesaukee, *Alfred Rehder*, no. 1081, Aug. 16, 1927 (A).

PENNSYLVANIA: Henderson Station, Montgomery County, *Jas. Crawford*, June 1, 1895 (P); Strafford, Chester County, *Edwin B. Bartram*, no. 1517, June 11, 1911 (A).

DISTRICT OF COLUMBIA: waste ground, *E. S. Steele*, May 28, 1898 (A).

NORTH CAROLINA: Salem, ex Schweinitz Herb. (P); Wilmington, *C. S. Williamson*, Aug. 1892 (P).

ALABAMA: ex Torrey Herb. (without locality or date) (G).

MISSISSIPPI: Yazoo City, *T. G. Harbison*, no. 25, May 1, 1915 (A).
OHIO: Cleveland, *L. D. Starr*, no. 6254, May 19, 1896 (G).
INDIANA: Shelby, Lake County, *C. C. Deam*, no. 20134, June 6, 1916 (G); Monroe, Knox County, *C. C. Deam*, no. 38676, June 4, 1923 (A); Decker, Knox County, *C. C. Deam*, no. 17050, July 8, 1915 (A); Cannelton, Perry County, *C. C. Deam*, no. 16616, June 29, 1915 (A); North, Ohio County, *C. C. Deam*, no. 48553, May 29, 1930 (A).
ILLINOIS: Port Byron, *E. T. & S. A. Harper*, June 1898 (A); Salem, *M. S. Bebb*, 1860 (G); Fountaindale, *M. S. Bebb*, 1870 (G); Davenport, La Salle County, *J. M. Greenman, O. E. Lansing, Jr. & R. A. Dixon*, no. 136, June 1–7, 1909 (G); Grand Tower, *Allen Gleason*, no. 1786, Aug. 17, 1900 (G); Starved Rock, La Salle County, *J. M. Greenman, O. E. Lansing, Jr. & R. A. Dixon*, no. 14, June 1–7, 1909 (G); *H. C. Skeels*, no. 628, May 30, 1905 (G); Aurora, *T. E. Boyce*, no. 572, June 1, 1884 (G); Peoria, *F. E. McDonald*, May 1904 (G); Cairo, Alexander County, *E. J. Palmer*, no. 23767, Sept. 17, 1923 (A); Aurora, *F. L. Bassett*, 1881 (P).
KENTUCKY: Brandenberg, *C. W. Short*, 1842 (P); Wickliffe, *Frank T. McFarland & W. A. Anderson, Jr.*, no. 189, Aug. 17, 1923 (A); Owensboro, Daviess County, *E. J. Palmer*, no. 17821, June 10, 1920 (A).
TENNESSEE: Memphis, *A. Fendler*, May 10, 1851, Aug. 28, 1853, 1855 (G); Reelfoot Lake, *Samuel L. Bain*, no. 402, June, 1903 (G).
MINNESOTA: St. Anthony, *J. H. Schuette*, June 2, 1888 (G); Swan Lake, Nickolet County, *C. A. Ballard*, June, 1892 (G); Lake City, *Warren H. Manning*, June 25, 1883 (G); St. Paul, ex Charles E. Smith Herb., June, 1872 (P).
IOWA: Ames, *C. R. Ball & Royal Meeker*, no. 525, June 21, 1897 (G); Carroll, *L. H. Pammel*, July 2, 1898 (G).
MISSOURI: Kennett, *C. S. Sargent & Wm. Trelease*, April 24, 1897 (A); Grain Valley, *B. F. Bush*, no. 10498, May 28, 1926 (A); Monteer, *B. F. Bush*, no. 9846, Aug. 5, 1922 (A); Dumas, *B. F. Bush*, no. 5922, Aug. 8, 1908 (A); Allenton, *Geo. W. Letterman*, 1897 (A, P); Creve Coeur Lake, St. Louis County, *Moses Craig*, June, 1909 (A); Galena, Stone County, *E. J. Palmer*, no. 5702, May 21, 1914; Novinger, Adair County, *E. J. Palmer*, no. 25545, June 16, 1924 (A); Monticello, Lewis County, *E. J. Palmer*, no. 35907, May 20, 1929 (A); Osceola, St. Clair County, *E. J. Palmer*, no. 35653, May 6, 1929 (A); Hickory County, *E. J. Palmer*, no. 35979, May 22, 1929 (A); Joplin, Jasper County, *E. J. Palmer*, no. 22891, May 28, 1923 (A); Alba, Jasper County, *E. J. Palmer*, nos. 4350, 30106, Sept. 16, 1913, May 15, 1926 (A); Forest Mill, Jasper County,

E. J. Palmer, no. 25323, June 4, 1924 (A); Columbus, Johnson County, *E. J. Palmer*, no. 36646, June 21, 1930 (A).

ARKANSAS: Decatur, Benton County, *D. Demaree*, no. 4644, Oct. 15, 1927 (A); War Eagle, Benton County, *D. Demaree*, no. 5429, Sept. 16, 1928 (A); Avoca, Benton County, *D. Demaree*, no. 6664, May 17, 1929 (A); Greenland, Washington County, *D. Demaree*, no. 3025, May 12, 1927 (A); Fayetteville, Washington County, *E. J. Palmer*, no. 23262, June 13, 1923 (A); Midway, Sebastian County, *E. J. Palmer*, no. 33281, April 8, 1928 (A); Magazine Mountain, Logan County, *E. J. Palmer*, no. 23242, June 11, 1923 (A); Little Rock, Pulaski County, *E. J. Palmer*, no. 24443, April 21, 1924 (A); Mesa, Prairie County, *E. J. Palmer*, no. 25071, May 22, 1924 (A); Hot Springs, Garland County, *E. J. Palmer*, nos. 24907, 29136, May 14, 1924, Oct. 11, 1925 (A); Fulton, *B. F. Bush*, no. 2451, April 26, 1905 (A).

KANSAS: Augusta, *S. F. Poole*, no. 23, May, 1903 (G); Neodesha, Wilson County, *E. J. Palmer*, nos. 21163, 21396, May 5, 23, 1922 (A); Arkansas City, Cowley County, *E. J. Palmer*, no. 21233, May 11, 1922 (A); Downs, Osborn County, *E. J. Palmer*, no. 21336, May 20, 1922 (A); Ellsworth, Ellsworth County, *E. J. Palmer*, no. 21270, May 13, 1922 (A); Harper, Harper County, *E. J. Palmer*, no. 21199, May 8, 1922 (A).

MISSISSIPPI: Yazoo City, *T. G. Harbison*, no. 25, May 1, 1915 (A).

Plants that are assigned to this species and its varieties vary greatly in the size, shape, and number of the leaflets, and in the amount of pubescence, as well as to some extent in the shape and size of the fruit. Species based upon slight differences in these characters, such as *Amorpha fragrans* Sweet and *Amorpha tennesseensis* Shuttl., although appearing distinct in extreme forms, are often indistinguishable, as there is a complete gradation of intermediate forms, and it seems best therefore to treat them as varieties of one species. *Amorpha occidentalis* of the Pacific coast and the Southwest and *A. croceolanata* of the Gulf coastal plain are also closely related to *A. fruticosa*, the former not always easily distinguishable morphologically from *A. fruticosa* var. *angustifolia;* and while the latter is more outstanding from the character of its pubescence and the size and shape of the leaflets, it is a matter of opinion whether they should be regarded as distinct species, as they are treated in this paper, or as varieties of *A. fruticosa*, as has been done by some authors.

The following forms have been distinguished, mostly based on cultivated plants:

Amorpha fruticosa f. **albiflora** Sheldon in Bull. Geol. Surv. Minn. IX. 72 (1894).

Flowers white. This form is found also in cultivation.

Amorpha fruticosa f. **pendula** C. Schneider, Ill. Handb. Laubholzk. II. 73 (1907).

Amorpha pendula Carrière in Rev. Hort. 1869, 340.
Amorpha fruticosa b. *pendula* Dippel, Laubholzk. III. 691 (1893).

Distinguished by its slender recurved branches. Occasionally cultivated in American and European gardens.

Amorpha fruticosa f. **crispa** C. Schneider, Ill. Handb. Laubholzk. II. 72 (1897).

Amorpha fruticosa var. *crispa* Kirchner, Arb. Musc. 370 (1864).

Distinguished by the crisped margins of the leaves. In cultivation.

Amorpha fruticosa f. **humilis,** comb. nov.

Amorpha humilis Tausch in Flora, XXI. 750 (1838).
Amorpha fruticosa var. c. *humilis* C. Schneider, Ill. Handb. Laubholzk. II. 73 (1907).

A low form, often dying back to the ground each season. In cultivation.

Amorpha fruticosa f. **coerulea,** comb. nov.

Amorpha coerulea Lodd. Cat. (1830) ex Loudon, Arb. Brit. II. 607 (1838), nomen nudum.
Amorpha fruticosa var. 5. *coerulea* Loudon, Arb. Brit. II. 607 (1838).

A form in cultivation and sometimes found growing spontaneously with the type, from which it is distinguished by its pale blue flowers.

Amorpha fruticosa f. **aureo-variegata** Schwerin in Mitteil. Deutsch. Dendr. Ges. XVI. 255 (1907).

A form in cultivation, with variegated foliage.

20a. **Amorpha fruticosa** var. **angustifolia** Pursh, Fl. Am. Sept. 466 (1814).—Fig. 20a.

Amorpha nana Sims in Bot. Mag. XLVII. t. 2112 (1819).—Not Nuttall.
Amorpha fragrans Sweet, Brit. Fl. Gard. III. t. 241 (1828).
Amorpha Lewisii Lodd. Cat. (1830), ex Loudon, Arb. Brit. II. 607 (1838).
Amorpha fruticosa 4. *Lewisii* Loudon, Arb. Brit. II. 607 (1836).
Amorpha angustifolia Boynton in Biltmore Bot. Studies, I. 139 (1902).

Differs from the type in its usually narrower elliptic leaflets, narrowed or cuneate at the base, and in the more sparse, appressed, pubescence.

Wisconsin and Minnesota to Saskatchewan and southward to Kansas, Texas and northern Mexico. Occasionally escaped farther east.

MASSACHUSETTS (introduced): Boston, *Charles F. Batchelder*, June 8, 1918 (G).

WISCONSIN: St. Croix Falls, *C. F. Baker*, July 16, 1900 (G); Alma, Buffalo County, *E. J. Palmer*, no. 27833, June 10, 1925 (A); Fountain City, Buffalo County, *Huron H. Smith*, no. 7196, July 8, 1922 (A).

MINNESOTA: Cannon Falls, *J. H. Sandberg*, no. 357. July, 1891 (A).

NORTH DAKOTA: Bismarck, *Esther L. Larsen*, no. 171, Aug. 14, 1927 (G).

SOUTH DAKOTA: Missouri River Valley, Union County, *W. R. Wilcox*, Aug. 27 (A); Cottonwood Creek, Bad River, *T. A. Williams*, (G); Sioux Falls, *T. A. Williams*, June 5, 1896 (A); Big Stone, *T. A. Williams*, no. 161, Aug. 15, 1894 (A); Rapid City, Pennington County, *E. J. Palmer*, no. 37318, June 16, 1929 (A); Hot Springs, Fall River County, *E. J. Palmer*, no. 37440, June 21, 1929 (A); Pine Ridge Indian Reservation, Washabaugh County, *E. J. Palmer*, no. 37638, June 29, 1929 (A).

NEBRASKA: Thedford, Thomas County, *P. A. Rydberg*, no. 1314, Sept. 8, 1893 (G); Red Cloud, *J. M. Bates*, no. 2263, June 22, 1903 (G); Ponca, *Fred Clements*, no. 2538, June 14, 1893 (G); Butler County, opposite Columbus, *E. J. Palmer*, no. 36063, June 5, 1929 (A).

MISSOURI: Grain Valley, *B. F. Bush*, no. 6992, May 24, 1913 (A).

KANSAS: Osburn City, Osburn County, *C. L. Shear*, nos. 45, 168, May 26, July 20, 1894 (G); Riley County, *J. B. S. Norton*, nos. 89, 89a, 1895, 1896 (G).

COLORADO: Ft. Collins, *C. S. Crandall*, no. 1241, June 12, 1896 (G, P); no. 15, June 14, Oct. 3, 1893 (G); Wolhurst, Douglas County, *I. W. Clokey*, no. 3802, July 8, 1920 (G, P); Ft. Collins, *J. H. Cowan*, no. 127, June 13, 1895 (G).

ARKANSAS: Marion County, opposite Cotter, *E. J. Palmer*, no. 5935, June 12, 1914 (A).

OKLAHOMA: Fonts, Lincoln County, *Clara Nevins*, May 5, 1895 (G); Tulsa, Tulsa County, *G. W. Stevens*, no. 2993, Oct. 30, 1913 (A, G); Knowles, Beaver County, *G. W. Stevens*, no. 520, May 19, 1913 (A, G); Pawhoska, Osage County, *G. W. Stevens*, no. 1937, Aug. 8, 1913 (A, G); Page, Le Flore County, *G. W. Stevens*, nos. 1393, 2620, April 20, Sept. 6, 1913 (G); Canton, *D. M. Andrews*, Aug. 15, 1915 (A); along Little River, Pushtamaha County, *E. L. Little, Jr. & C. E. Olmstead*, no. 536, July 5, 1930 (A); Sapulpa, *B. F. Bush*, no. 1105, May 1, 1895 (A); Youkon, Canadian County,

E. J. Palmer, no. 22134, Sept. 29, 1922 (A); Tishomingo, Johnston County, *E. J. Palmer*, no. 6441, Sept. 8, 1914 (A); Sapulpa, *C. B. Williams*, May 21, 1924 (P).

New Mexico: *A. Fendler*, no. 126, 1847 (G); Kingston, *O. B. Metcalf*, no. 930, May 24, 1904 (G).

Arizona: Willow Springs, *Edward Palmer*, no. 484, June 10–20, 1890 (G).

Texas: *F. Lindheimer* (without locality), nos. 595, 1847 (G, P); 742, 1850 (G, P); *V. Havard*, nos. 2, 3 (without locality), July, 1881 (G); Texas, *Charles Wright* (without locality or date) (G); Cibilo Creek, *V. Havard*, no. 1, May, 1881 (G); Burton, *Elihu Hall*, no. 127, May 26, 1872 (G, P); Kerrville, *A. A. Heller*, no. 1596, April 19–25, June 26–30 (A, G, P); Dallas, *J. Reverchon*, no. 223, June, Sept. 1880 (A); Dallas, *J. Reverchon*, no. 145, May, 1874 (G); Austin, *M. S. Young*, no. 38, April 15, 1918 (G); Kinney County, *V. L. Corey*, no. 377, April 17, 1929 (G); White's Ranch, Chambers County, *B. C. Tharp*, no. 3138, Sept. 3, 1924 (A); Dallas, *B. F. Bush*, no. 692, May 10, 1900 (A); Southeast Texas, *E. N. Plank* (A); *Lincecum* (without locality or date) (P); Kerrville, Kerr County, *E. J. Palmer*, no. 33827, May 7, 1929 (A); Tivoli, Refugio County, *E. J. Palmer*, no. 9253, March 22, 1916 (A); San Saba, San Saba County, *E. J. Palmer*, no. 11822, May 5, 1917 (A); Devil's River, Valverde County, *E. J. Palmer*, no. 11387, March 26, 1917 (A); Gamble's Ranch, Armstrong County, *E. J. Palmer*, no. 13967, June 6, 1918 (A); Brownwood, Brown County, *E. J. Palmer*, no. 26798, Oct. 31, 1924 (A); Sweetwater, Nolan County, *E. J. Palmer*, no. 33975, May 15, 1928 (A).

Manitoba: *John Macoun*, no. 12511, Aug. 7, 1896 (G).

Mexico: Casas Grandes, Chihuahua, *E. A. Goldman*, no. 405, May 12, 1899 (G); Paso del Norte, Chihuahua, *C. G. Pringle*, no. 1221, May 10, Aug. 12, 1887 (G, P).

Cultivated for many years in American and European gardens, often under the name *Amorpha Lewisii*.

Amorpha fruticosa var. **angustifolia** f. **glabrata,** forma nov.

A typo varietatis recedit ramulis foliisque glabris vel fere glabris.

Texas: Kurten, Brazos County, *E. J. Palmer*, no. 13479 (type), April 28, 1918 (A).

A plant that may be referred to this form which differs from typical var. *angustifolia* in the branches and foliage being nearly or entirely glabrous, is in cultivation at Highland Park, Rochester, N. Y. A specimen collected by E. H. Costich, July 17, 1915, bears the notation: "very late flowering." (A).

20b. **Amorpha fruticosa** var. **tennesseensis,** comb. nov.—Fig. 20b.

Amorpha tenesseensis Shuttleworth in Kunze, Delect. Sem. Hort. Lips. 1848, p. 1 adn. ex Walpers, Ann. Bot. Syst. II. 360 (1851); Linnaea, XXIV. 191 (1851).

Differs fron the type in the often more numerous, narrow-oblong leaflets, and in the slightly curved or nearly straight pod.

North Carolina to Florida and west to Kansas, Oklahoma and Texas.—Type locality: Dandridge, Tennessee.

NORTH CAROLINA: Swain County, *H. C. Beardsley & C. O. Kofoid*, July 17, 1891 (G); Falls of Yadkin River, Stanley County, *J. K. Small*, Aug. 18, 1892 (G).

TENNESSEE: Dandridge, *Rugel*, June–Sept., 1842 (isotype) (G); Ocoee River, Polk County, no. 1381a, ex Biltmore Herb., Oct. 5, 1897 (G); Cleveland, *E. E. Magee*, Oct. 1, 1897 (G).

ILLINOIS: Fall Creek, Adams County, *J. Davis*, no. 3226, Sept. 16, 1894 (A); Wady Petra, *Virginius H. Chase*, no. 737, Aug. 14, 1900 (P).

KENTUCKY: Eddyville, Lyons County, *E. J. Palmer*, no. 32712, Sept. 14, 1923 (A).

MISSOURI: Joplin, Jasper County, *E. J. Palmer*, nos. 21956, 21968, Sept. 14, 1922 (A); Noel, McDonald County, *E. J. Palmer*, no. 4156, Sept. 16, 1918 (A); Branson, Taney County, *E. J. Palmer*, no. 19232, Sept. 29, 1920 (A).

ARKANSAS: Van Buren, *G. M. Brown*, Aug. 8, 1909 (A); Baker Springs, Howard County, *J. H. Kellogg*, Oct. 5, 1909 (A); Blue Mountain, Logan County, *E. J. Palmer*, no. 24217, Oct. 18, 1923 (A); Hot Springs, Garland County, *E. J. Palmer*, no. 24251, Oct. 20, 1923 (A); Mesa, Prairie County, *E. J. Palmer*, no. 24333, Oct. 24, 1923 (A).

KANSAS: Galena, Cherokee County, *E. J. Palmer*, no. 21979, Sept. 15, 1922 (A); Neodesha, Wilson County, *E. J. Palmer*, no. 22033, Sept. 19, 1922 (A); Arkansas City, Cowley County, *E. J. Palmer*, no. 22073, Sept. 26, 1922 (A); Ellsworth, Ellsworth County, *E. J. Palmer*, no. 38163, Aug. 3, 1930 (A).

OKLAHOMA: Page, LeFlore County, *G. W. Stevens*, no. 2620, Sept. 6, 1913 (A); Page, LeFlore County, *E. J. Palmer*, nos. 20601, 22259, Sept. 23, 1921, Oct. 10, 1922 (A); Hugo, Choctaw County, *E. J. Palmer*, no. 24068, Oct. 7, 1923 (A).

ALABAMA: Cullman, *T. G. Harbison*, no. 3, Nov. 3, 1919 (A); Alabama, *Buckley* (without locality or date) (G).

CULTIVATED: Arnold Arboretum.

20c. **Amorpha fruticosa** var. **oblongifolia,** var. nov.—Fig. 20c.

A typo recedit foliolis oblongis vel lineari-oblongis, 20–50 mm.

longis, 8–16 mm. latis, glabris vel infra minute scabro-pubescentibus.

An erect shrub 2–3 m. high. Leaves 1.5–2.5 dm. long; petioles 2–3 cm. long; leaflets 21–41, oblong or narrowly oblong, 2–5 cm. long, 0.5–1.5 cm. wide, rounded at both ends or slightly emarginate at mucronate apex, and rarely abruptly narrowed at base, thin but firm, dark green and glossy above, much paler or sometimes slightly glaucous, black-punctate and glabrous or sparsely scabrous-pubescent beneath; petiolules slender, 1.5–2 mm. long. Inflorescence of a few or several erect spikes 0.8–2 dm. long; calyx glabrous, its lobes much shorter than the tube, the two upper ones low and rounded, the lower broadly triangular. Pod 7–9 mm. long, 3 mm. wide, somewhat curved dorsally, with short erect beak, glandular dotted.

Missouri and Arkansas. Type locality: Helena, Phillips County, Arkansas.

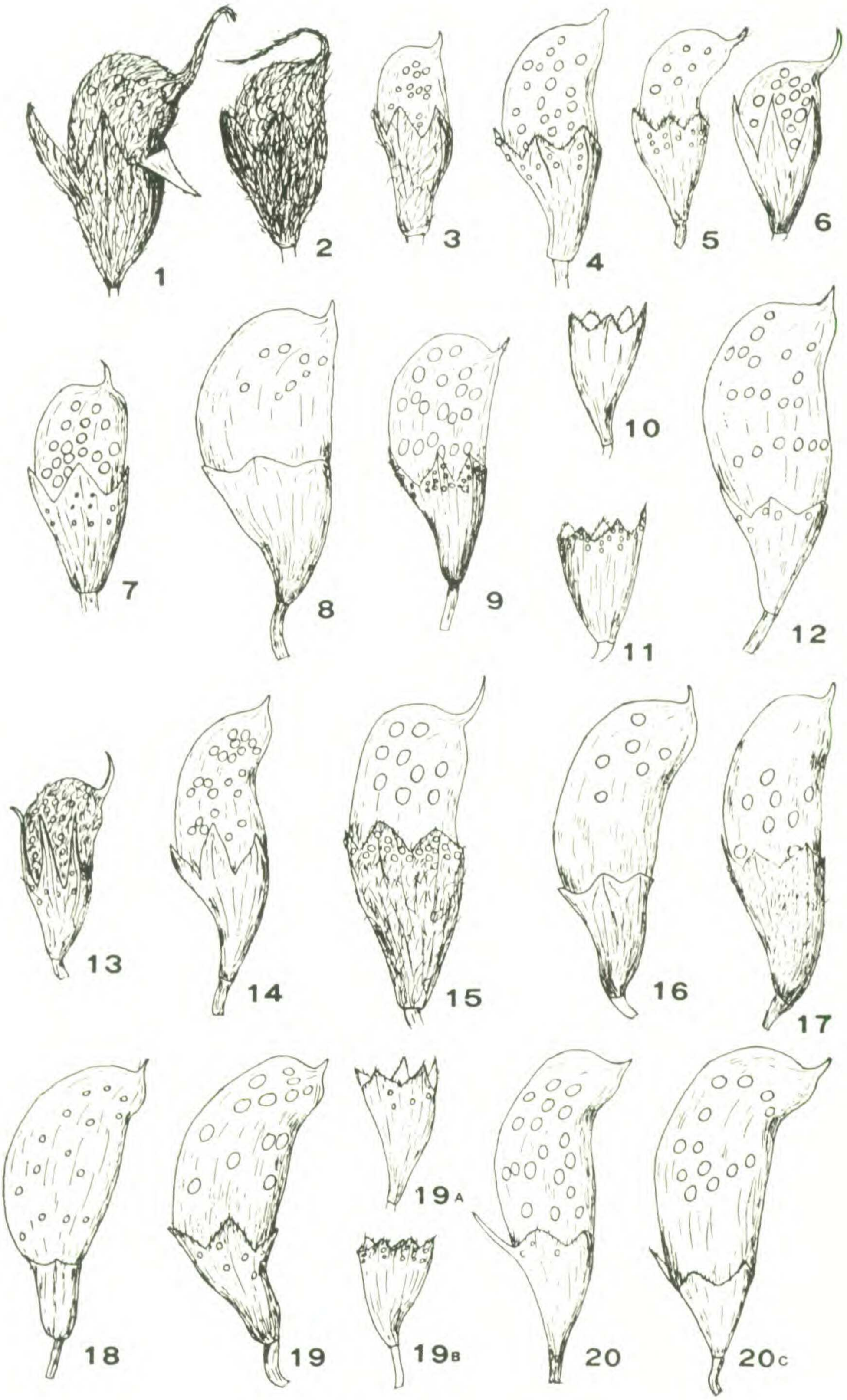
Missouri: Watson, Atchison County, *E. J. Palmer*, no. 19010, Sept. 4, 1920 (A); Purcell, Jasper County, *E. J. Palmer*, no. 22182, Oct. 3, 1922 (A).

Arkansas: Marion County, opposite Cotter, *E. J. Palmer*, no. 20659, Oct. 3, 1921 (A); Helena, Phillips County, *E. J. Palmer*, no. 26628 (type) Oct. 17, 1924 (A); Forrest City, St. Francis County, *E. J. Palmer*, no. 29278, Oct. 17, 1925 (A).

This is a very distinct looking variety, on account of its numerous, crowded, narrowly oblong leaflets. It may when better known prove to be a distinct species, but it seems safest at present to treat it as a variety of the polymorphous species *A. fruticosa*, since I have not seen the flowers and some of the specimens in which the leaf characters are best marked are without fruit, while certain specimens of *A. fruticosa* or the var. *tennesseensis* approach it. The leaflets in shape and number resemble most closely those of *A. fruticosa* var. *tennesseensis*, but they are usually much larger and differ in being glabrous or sparingly short-pilose or scabrate. The essentially glabrous branches and leaf rachises and the glabrous calyx also serve to distinguish it. The leaflets also resemble in size, shape, and texture those of *A. Bushii*, but they differ from those of the southeastern species in the absence of loose villous pubescence as well as in the shape of the fruit. The calyx in *Amorpha fruticosa* var. *oblongifolia* is entirely glabrous, at least in fruiting specimens, and the teeth are almost as short as in *A. glabra*. The fruit is slightly larger than in typical *A. fruticosa*, but is similarly curved on the back.

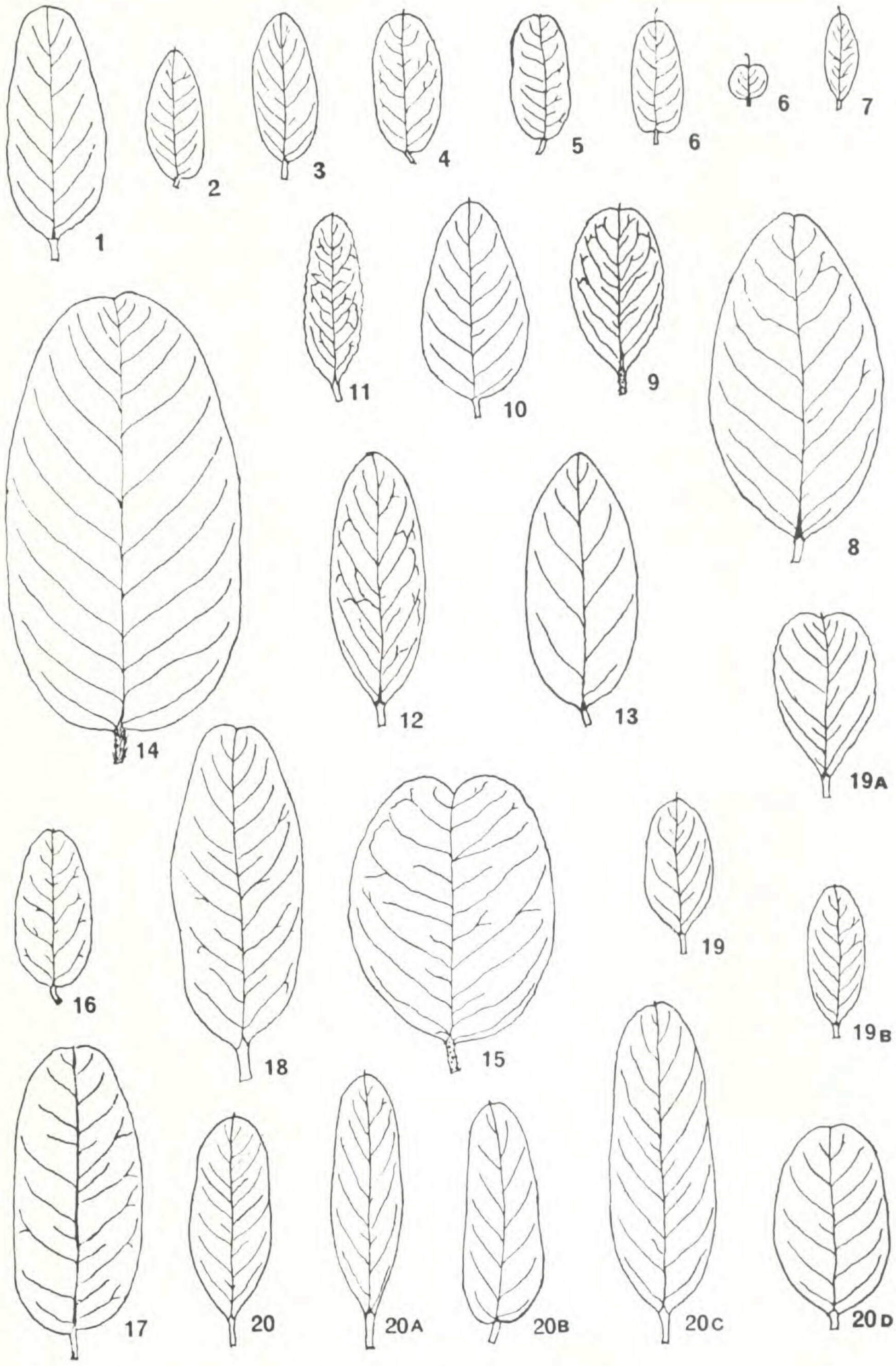
20d. **Amorpha fruticosa** var. **emarginata** Pursh, Fl. Am. Sept. II. 466 (1814).—Fig. 20d.

Amorpha emarginata Sweet, Hort. Brit. ed. 1, 121 (1827).



FRUITS OF AMORPHA (× 5 ½–6)

(The figure numbers correspond with the numbers of the species in the text)



LEAFLETS OF AMORPHA (XI)

(The figure numbers correspond with the numbers of the species in the text)

Differs from the type in the usually larger, oval or ovate leaves, blunt or emarginate at the apex.

Mississippi to Arkansas and Illinois.

ILLINOIS: Crawford Bridge, Macon County, *I. W. Clokey*, no. 2382, May 31, 1915 (G); Decatur, *I. W. Clokey*, no. 2703, May 29, 1899 (G); Decatur, *Allan Gleason*, no. 825, May 21, 1899 (G); Mahomet, *Allan Gleason*, no. 2414, May, 1901 (G); Cairo, Alexander County, *E. J. Palmer*, no. 15082, May 8, 1919 (A).

MISSOURI: Webb City, *B. F. Bush*, no. 553, May 20, 1901 (A).

ARKANSAS: Newport, Jackson County, *E. J. Palmer*, no. 35528, April 26, 1929 (A).

TENNESSEE: cliffs of Cumberland River, Nashville, *A. Gattinger*, no. 130 (A); Shepards, Haywood County, *E. J. Palmer*, no. 17470, May 13, 1920 (A).

Cultivated in American and European gardens.

This variety is in some respects intermediate between typical *Amorpha fruticosa* and *A. croceolanata*, somewhat resembling the latter in the shape and size of the leaflets, but differing in its gray, less copious pubescence.

DOUBTFUL SPECIES AND VARIETIES, AND NAMES EXCLUDED FROM THE GENUS

Amorpha caroliniana Croom in Am. Jour. Sci. XXV. 74 (1834).

No specimens have been seen which agree with the original description. See remarks under 4. *A. cyanostachya* M. A. Curtis on p. 170.

Amorpha fruticosa var. *fragrans* Bean, Trees & Shrubs, I. 193 (1914).

From the brief description this is apparently not identical with *A. fruticosa* var. *angustifolia* (*A. fragrans* Sweet). Undeterminable.

Amorpha fruticosa β *pumila* Wenderoth in Schrift. Ges. Beförd. Naturw. Marburg, II. 259 (1831). This may possibly be the same as *A. humilis* Tausch (= *A. fruticosa* f. *humilis*), but description is too indefinite to show clearly to what form it refers.

Amorpha Gaertnerii Hort. ex K. Koch, Dendr. I. 70 (1869), nomen nudum.

Amorpha Gardnerii Hort. ex Kirchner, Arb. Musc. 370 (1864), nomen nudum.

Amorpha glandulosa Blanco, Fl. Philipp. ed. I. 553 (1837) = PAROSELA GLANDULOSA (Blanco) Merrill in Philipp. Jour. Sci. V. 68 (1910).

Amorpha lutea Rafinesque, Fl. Ludov. 105 (1817). Undeterminable and apparently does not belong to the genus.

Amorpha pedalis Blanco, Fl. Philipp. ed. I. 555 (1837) = SOLOMONIA CILIATA (L.) DC., fide Merrill, Spec. Blanc. 214 (1918).

Amorpha Rabiae Lexarza in Lexarza & La Llavé, Nov. Veg. Desc. fasc. I. 22 (1824).[1]

Amorpha tomentosa ? Rafinesque, Fl. Ludov. 105 (1817). Undeterminable and probably not an Amorpha.

Amorpha crocea, *A. dealbata*, *A. elatior*, *A. ludoviciana*, *A. marginata* Hort. ex Lavallée, Arb. Segrez. 60 (1877), nomina nuda.

ON THE OCCURRENCE OF CASUARINA NODIFLORA FORST. IN AUSTRALIA

C. G. G. van Steenis

Casuarina nodiflora Forster, Fl. Ins. Austr. Prodr. 64 (1716).

Northeast Queensland: Mt. Alexander, collected for the Arnold Arboretum by *S. F. Kajewski*, no. 1492 (Arnold Arb. Exped.), Feb. 17, 1929 (small tree up to 7 m. high, common in poor scrub on top of the mountain).

This species is somewhat variable in habit, the specimen being a mountain form with densely crowded short branchlets. It differs from most other specimens by the short ferrugineous pubescence remaining on the bracts as well as on the bracteoles of the fruiting cones. In other specimens this short tomentum is more scanty and soon disappears in the fruiting state.

I can find no sound differences between this and the East-Malaysian *C. Rumphiana* Miq. which in my eye ought to be referred to *C. nodiflora* Forst. as a synonym. If this is adopted the area of *C. nodiflora* adequately extends from the Fiji Islands, New Caledonia, Queensland and New Guinea to the Moluccas, Selebes (Celebes) and Philippines and overlaps the area of *C. sumatrana* Jungh.

The cones of the Malaysian specimens are usually described as much smaller but it should be borne in mind that also in immature cones the bracteoles spread when dried, except in the extremely young ones. In those opened immature cones the bracteoles are much less thickened than in the ripe ones and the unripe fruits are more or less wrinkled. I doubt whether the cones and fruits are fully developed in this specimen. Prof. L. Rutten collected the species in Central Séran (Ceram) at 1400 m. altitude and his specimen shows the same crowded mountainous habit as that collected by Kajewski.

Herbarium, Buitenzorg, Java

[1] A synopsis of the author's description of this species is as follows:

Herbaceous ?, 2 ft. high; stems terete, smooth; leaflets ovate, acute, tomentose; racemes axillary, fascicled; bracts short, acute; calyx cup-shaped, obscurely 6-lobed [!], tomentose without; calyx-lobes obtuse; standard obovate or cuneiform, white, slightly keeled; ovary covered with lanate or silky tomentum; style short, incurved; pod one-seeded, glandular; seed reniform.

The type specimen was collected on Mount Quinceo, in the state of Michoacan, southern Mexico, and apparently it has not been found or recognized since.

CHROMOSOME NUMBERS IN THE LIGNEOUS SAXIFRAGACEAE

KARL SAX

Plate 37

The ligneous Saxifragaceae include genera which differ considerably in morphological characters. These differences are so extreme that Hutchinson (1926) has divided this group of plants into three families; the Escalloniaceae, the Grossulariaceae and the Hydrangeaceae. Different genera also vary greatly in the number and distribution of species. Some of them, such as *Carpenteria* and *Whipplea*, are monotypic and endemic in western North America while others, such as *Ribes* and *Hydrangea*, contain numerous species and are widely distributed.

A study of chromosome number was made to determine whether the variability found in this family has a cytological basis and if the number of species in larger genera is associated with polyploidy.

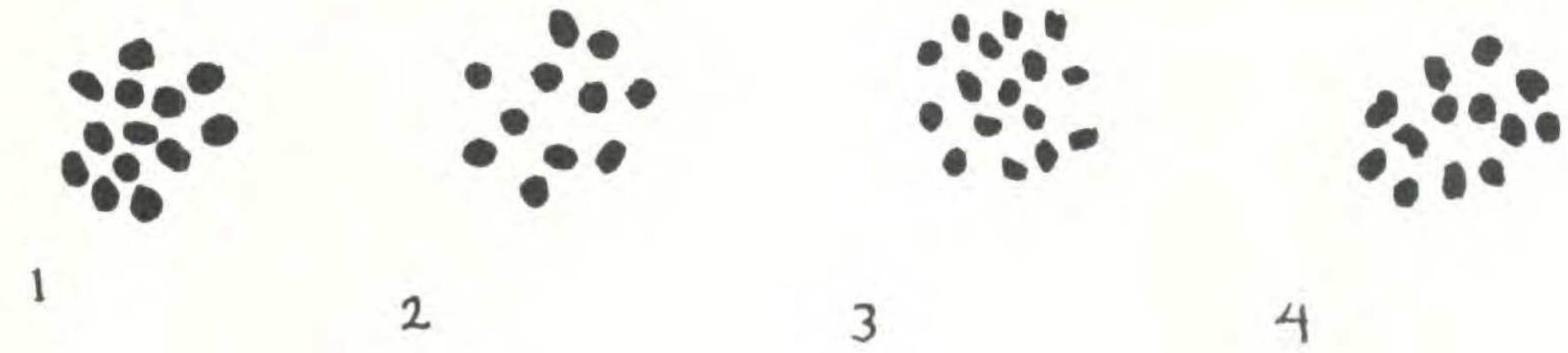
The Arnold Arboretum contains many species of the representative genera of the Saxifragaceae, both American and Asiatic. Most of the chromosome counts were obtained from aceto-carmine smears of pollen mother-cells. The taxonomic grouping is based on Rehder's (1926) Manual.

The following table shows the chromosome numbers, number of species and distribution of the genera studied.

Saxifragaceae

Genus	Chromosome number	Number of Species	Habitat
Philadelphus	13	40	N. America, Asia, Europe
Fendlera Wrightii	11	3	N. America
Jamesia	16	3	Western N. America
Deutzia	13–65	50	Asia, N. America
Decumaria	14	2	Asia, N. America
Hydrangea	18–36	35	Asia, N. & S. America
Schizophragma	14	3	Asia
Itea	11	11	Asia, N. America
Ribes	8	150	N. Hemisphere, S. America

The genus *Philadelphus* is well represented by both American and Asiatic forms. Bangham (1929) obtained chromosome counts of 9 American species, 12 Asiatic species and a number of hybrids and varieties. In all cases the haploid chromosome number was found to be 13. In the hybrids studies there was no indication of any chromosome irregularity. Two of the hybrids investigated were between species which are natives of different parts of the world. These species, or their ancestors, were probably separated



CHROMOSOME NUMBERS IN SAXIFRAGACEAE

long before the Glacial Period and yet their chromosomes are so similar that there is complete pairing of chromosomes. Species hybrids are very common in this genus wherever different species are brought together in gardens, and it is quite possible that all of the species of the genus can be inter-crossed freely.

The three species of *Fendlera* are found distributed from Colorado to New Mexico. *Fendlera Wrightii* is the only species represented in the Arboretum and it has 11 pairs of chromosomes.

Jamesia is found only in western North America and contains 3 closely related species, only one of which is described by Rehder. The haploid chromosome number of *J. americana* is 16.

Most of the 50 or more species of *Deutzia* are natives of Asia, but two species representing a distinct section (*Neodeutzia*) are found in Mexico. The chromosome numbers of representative species and hybrids are given in Table II. The basic chromosome number is 13 for this genus, but many species are polyploids. The chromosome numbers seem to be closely correlated with taxonomic grouping in some cases. *Deutzia Schneideriana* and *D. scabra* are morphologically similar and both species have 65 pairs of chromosomes. *D. discolor*, *reflexa* and *Vilmorinae* constitute another group of similar species, each with 52 pairs of chromosomes. *D. mollis* with about 39 pairs of chromosomes is a very distinct species, and other species with the basic chromosome number 13, may vary considerably in taxonomic characters. An interesting case of autopolyploidy is found in *D. parviflora* where the variety *ovatifolia* has 39 instead of 13 chromosomes. This hexaploid variety differs only slightly from the diploid form. The hexaploid variety is perhaps somewhat later in time of flowering, but the two forms are not growing under comparable conditions in the Arboretum. In general the species with the higher chromosome numbers are much later in time of flowering and have thicker stems and more fleshy receptacles than the diploid forms. The pollen grains of the polyploid species are somewhat larger than those of diploids but the difference is not proportional to the differences in chromosome number. All of the species studied produce good pollen with the exception of *D. mollis* where about 10 per cent of the pollen grains are obviously aborted. The chromosomes of the polyploid species usually form only bivalents at meiosis due presumably to the low frequency of chiasma formation between homologous chromosomes.

Among the species hybrids in the genus only one, *D. candelabrum*, was found to be fertile. The others listed in Table II are highly or completely sterile as indicated by the condition of the pollen.

In the unbalanced polyploid species there is of course considerable chromosome irregularity but in some of the sterile hybrids between 13 chromosome species the chromosomes usually pair and divide with little or no irregularity, but a large proportion of the pollen grains do not develop completely. In the two unbalanced polyploid hybrids there is a tendency for trivalents to be formed so that the total number of paired chromosomes is usually less than that of the parent with the larger number.

Table II.

Species of Deutzia	Chromosome number
Sect. I.	
1. D. gracilis	13[1]
2. D. scabra	65[1]
3. D. Schneideriana	65
4. D. Sieboldiana	13
5. D. purpurascens	13?
6. D. discolor	52
7. D. reflexa	52
8. D. Vilmorinae	52
Sect. II.	
9. D. mollis	39
10. D. parviflora	13
11. D. parviflora ovatifolia	39
12. D. hypoglauca	13
Hybrids.	
13. D. candelabrum (1 × 4)	13
14. D. rosea (1 × 5)	13
15. D. magnifica (2 × 8)	$52_{II} + 13_{I}$
16. D. Wilsonii (S) (6 × 9)	42 – 44
17. D. Lemoinei (10 × 1)	13
18. D. candida (17 × 4)	13
19. D. maliflora (17 × 5)	13
20. D. Kalmiaeflora (5 × 10)	13

Decumaria is a small genus with only two species, one in southeastern United States and the other in China. The chromosome number of the American form, *D. barbara*, is 14.

There are about 35 species of *Hydrangea* distributed in North and South America and in Asia. Few natural hybrids are found in this group. The haploid chromosome number is 18 for the American species, *H. cinerea*, *H. quercifolia*, *H. arborescens*, and *H. radiata*. Of the three Asiatic species studied two, *H. Xanthoneura* and *H. petiolaris*, are diploid forms with 18 pairs of chromosomes, while the other, *H. paniculata praecox*, is a tetraploid with 36 chromosomes. According to the recent work of Schoennagel, *H. arborescens*, *aspera*, and *radiata* all have 36 somatic chromosomes.

[1] Recently reported by Schoennagel (1931).

There are 3 species of *Schizophragma*, all of Asiatic origin. The chromosome number of *S. hydrangeoides* is 14, the same as that found in *Decumaria*.

Itea is the only genus of Escalloniaceae available for study in the Arboretum. This genus is represented by about 10 species in Asia and one in southeastern United States. The American species *I. virginiana* has 11 pairs of chromosomes as reported by Schoennagel (1931).

Ribes has been separated into a third family, the Grossulariaceae (Hutchinson). This genus contains about 150 species widely distributed in the northern hemisphere and in South America. Meurman (1928) has found only 8 pairs of chromosomes in this genus although about 20 species were studied. The same counts were also obtained by Tischler (1927) and by Darlington (1927). Mr. Dermen of this laboratory found 8 pairs of chromosomes in each of the following species: *R. Giraldii*, *R. Grossularia*, *R. missouriense*, *R. cynosbati*, and *R. fasciculatum*. In certain species hybrids Meurman finds more or less irregularity in pairing which would indicate that there may be a genetic differentiation of chromosome sets in certain species. In many species hybrids, however, there is normal chromosome pairing at meiosis.

DISCUSSION

The chromosome numbers found in the Saxifragaceae are not closely correlated with the taxonomic grouping. In the Hydrangeaceae, where the genera seem to constitute a natural group, the basic chromosome numbers are 11 in *Fendlera*, 13 in *Philadelphus* and *Deutzia*, 14 in *Decumaria* and *Schizophragma*, 16 in *Jamesia*, and 18 in *Hydrangea*. This variation in chromosome number does not necessarily mean, however, that these genera have not had a common origin because a single genus may include species with different chromosome numbers. In fact the species of the genus *Saxifraga* have 11, 14, 16 or 28 chromosomes (Schoennagel 1931).

Both the taxonomic and cytological evidence indicate that *Philadelphus* and *Deutzia* are closely related as are *Decumaria* and *Schizophragma*, but *Fendlera* and *Itea* with the same chromosome numbers differ considerably in morphological characters.

Pollen grain measurements do not show much difference for the various genera, with the exception of *Ribes*. The pollen grains of *Ribes* are more than twice as large as those of the other genera, which may be some indication that this genus forms a rather distinct group of plants. (Hutchinson 1926).

In this family there are two large genera which show no variation

in chromosome number of the various species. There are about 40 species of *Philadelphus* and all of the species studied have 13 pairs of chromosomes. A considerable number of the 150 or more species of *Ribes* have been examined (Meurman, Tischler, and Darlington) and all have 8 pairs of chromosomes. In both genera species hybrids are numerous. In many of these species hybrids the chromosomes pair at meiosis and in some there is a high degree of fertility.

The species of *Philadelphus* are morphologically very similar, even though they are widely distributed. Of the species enumerated by Rehder 7 are found in China, 2 in Manchuria and Korea, 1 in Japan, 2 in the Himalayas, 1 in southeastern Europe, 5 along the west coast of North America, 6 in central and southeastern United States, and 3 in Colorado and New Mexico.

All of these species undoubtedly had a common origin. Species hybrids are numerous in this genus and it is probable that all species of *Philadelphus* will intercross freely. Hybrids have been obtained between such widely separated species as *P. pubescens*, a native of southern United States, and *P. tomentosus*, a native of the Himalayas; or between *P. pubescens* and the Pacific coast species *P. Gordonianus;* or between *P. laxus* of Georgia and *P. coronarius* of Europe. In certain species hybrids such as *P. pendulifolius*, which is supposed to be a cross between *P. pubescens* of Tennessee and Alabama and *P. laxus* of Georgia, the F_1 is highly fertile and the pollen grains are normal. In the hybrid *P. Lemoinei* a cross between American and European species, the chromosomes pair and the divisions are normal but most of the pollen grains do not mature. The female gametes must be functional, however, because this hybrid has produced numerous varieties when crossed with other species. In the hybrid, *P. maximus*, a cross between a Himalayan and an American species, the microspores disintegrate at an early stage and the plant is highly sterile.

Meurman (1923) finds a similar condition in *Ribes*. Closely related species from the same continent produce more or less fertile hybrids with normal chromosome pairing at meiosis. Hybrids between species from different continents were found to be highly sterile with various degrees of chromosome pairing.

Some of the species of *Philadelphus* and *Ribes* can apparently retain their identity only so long as they are isolated. In the course of species formation in these genera mutations must have occurred with geographic isolation. At the present time some of the species probably do not differ greatly in genetic constitution while others are so highly differentiated that fertile hybrids can no longer be

obtained between certain species. In *Philadelphus*, at least, the species are not sufficiently different to prevent crossing between most or perhaps all species of the genus. In view of the genetic and cytological analysis of these genera it would seem that the same factors which have produced varietal differences are responsible for species and in certain cases even generic differentiation (i. e. *Philadelphus* and *Deutzia*). Mutation seems to have been the basic factor in causing variation in *Philadelphus* and *Ribes* although it is possible that changes have occurred in chromosome structure.

It has often been assumed that the individuals within a species can cross freely with a high degree of fertility, while crosses between species result in partially or completely sterile hybrids (Babcock 1931). The fact that two individuals are inter-sterile does not necessarily mean that they belong to different species. Genetic factors, changes in chromosome structure, or autopolyploidy may be responsible for a high degree of sterility in varietal hybrids. On the other hand plants, which would be classed by the most conservative taxonomists as distinct species, are often interfertile. According to the species concept based on cyto-genetics some polymorphic genera would be reduced to a single species, while the number of species in other genera would be greatly reduced. Such a concept of a species seems hardly justified from the point of view of the taxonomist. However, the taxonomic status of certain genera, such as *Crataegus*, would be greatly improved if the taxonomist were required to make the cyto-genetic tests before naming a new species!

Perhaps it would be more practical to apply the cyto-genetic test to fundamental or basic species. These "basic species" would include all individuals which have similar genoms and which produce fertile hybrids. Even the cyto-genetic tests cannot draw precise lines between basic species because of various degrees of chromosome pairing and sterility in species hybrids. It is of interest to note that there is complete chromosome pairing in many species hybrids in *Philadelphus* and in *Deutzia*, but there is a high degree of pollen sterility in these hybrids.

Deutzia and *Philadelphus* are closely related and both have the same basic chromosome number, but one genus is uniform in chromosome number while the other contains a series of polyploid species. Why should *Philadelphus* be so uniform and *Deutzia* so variable in the chromosome number of different species? Polyploidy may be induced by genetic factors, by environmental conditions, and is probably dependent to some extent on the number

of chiasmata which unite the homologous chromosomes at meiosis.

In both *Philadelphus* and *Deutzia* there is apparently insufficient differentiation of chromosomes to prevent pairing of chromosomes in species hybrids. There is, however, a greater amount of morphological differentiation of the *Deutzia* species, even among those with the basic chromosome number. In certain species hybrids the chromosomes may fail to pair or are so loosely associated that environmental conditions would easily inhibit pairing. In such hybrids diploid gametes would be expected occasionally which would give rise to fertile intermediate polyploid species. Such types of new species have been produced in a number of genera (Clausen and Goodspeed 1925, Karpenchenko 1927, et al.) and recently Muntzing (1931) has been able to synthesize a widespread tetraploid Linnean species. It is possible that some of the polyploid *Deutzias* have been produced in this way.

Variations in temperature may also cause a semi-heterotypic division at meiosis and cause the production of tetraploid varieties. These tetraploids, since they are partially sterile when crossed with the diploid forms would serve as a basis for the development of new species by mutation even without geographic isolation. As Belling (1925) has suggested, the tropical or subtropical species might be more susceptible to the influence of low temperatures. In general, the species of *Deutzia* have a more southern range, are less hardy, and bloom earlier than the species of *Philadelphus*. The fact that the autopolyploid variety of *D. parviflora* is a hexaploid indicates that polyploidy has been due, in part at least, to the production of diploid gametes.

In both *Philadelphus* and *Deutzia*, and in the other genera of Saxifragaceae, the chromosomes at the first meiotic division are usually united by a single terminal or sub-terminal chiasma. There is apparently no difference in the chromosome pairing which would favor the production of diploid gametes in *Deutzia*.

Polyploidy in *Deutzia* may be due to greater differentiation of the chromosomes in different species and to the production of diploid gametes induced by low temperatures, facilitated perhaps by the low frequency of chiasma formation between homologous chromosomes at meiosis.

SUMMARY

The basic chromosome numbers of representative genera of the ligneous Saxifragaceae were found to be 13 in *Philadelphus* and *Deutzia*, 16 in *Jamesia*, 14 in *Decumaria* and *Schizophragma*, 18 in *Hydrangea*, 11 in *Fendlera* and *Itea*, and 8 in *Ribes*.

Deutzia contains many polyploid species, with numbers as high as 65 pairs of chromosomes, while the closely related genus *Philadelphus* contains only diploid species. The possible causes of these differences are discussed.

In both *Deutzia* and *Philadelphus* the chromosomes may pair in species hybrids and apparently normal microspores are produced, but the pollen is highly sterile in most of these hybrids.

Most, or perhaps all of the species of *Philadelphus* can be intercrossed freely and some of the hybrids are at least partially fertile. Species hybrids are also frequently found in *Deutzia* and in *Ribes*. Some of these species are apparently maintained as distinct units only by geographic isolation. The species concept is discussed in relation to the cyto-genetic analysis of certain genera.

CYTOLOGICAL LABORATORY, ARNOLD ARBORETUM
HARVARD UNIVERSITY

LITERATURE CITED

BABCOCK, E. B. (1931). Cyto-genetics and the species concept. (Amer. Nat. **65**: 5–18.)

BANGHAM, W. (1929). The chromosomes of some species of the genus Philadelphus. (Jour. Arnold Arb. **10**: 167–169.)

BELLING, J. (1925). Production of triploid and tetraploid plants. (Jour. Heredity 16: 463–464.)

CLAUSEN, R. E. & GOODSPEED, T. H. (1925). Interspecific hybridization in Nicotiana 11. (Genetics, **10**: 278–284.)

DARLINGTON, C. D. (1927). Reversion in black currants. (Jour. Pom. Hort. Sci. **6**: 242.)

HUTCHINSON, J. (1926). The families of flowering plants. MacMillan Co., London. 328 pp.

KARPECHENKO, G. D. (1928). Polyploid hybrids of Raphanus sativus L. Brassica oleracea L. (Zeit. Indukt. Abstamm. u. Vererb. **48**: 1–85.)

MEURMAN, O. (1928). Cytological studies in the genus Ribes L. (Hereditas, **11**: 289–356.)

MUNTZING, A. (1931). Ueber Chromosomenvermehrung in Galeopsis-Kreuzungen und ihre phylogenetische Bedeutung. (Hereditas, **14**: 153–172.)

SCHOENNAGEL, E. (1931). Chromosomenzahl und Phylogenie der Saxifragaceen. (Bot. Jahrb. **64**: 266–288.)

TISCHLER, G. (1927). Chromosomenstudien bei Ribes Gordonianum und seinen Eltern. (Planta, **4**: 617–650.)

DESCRIPTION OF PLATE 37

Chromosome numbers in Saxifragaceae. Drawing from aceto-carmine smears of pollen mother cells. × 2100. (M. = metaphase).

Fig. 1. *Philadelphus Schrenkii* . . . . . I M.
Fig. 2. *Fendlera Wrightii* . . . . . I M.
Fig. 3. *Jamesia americana* . . . . . 1st tel.
Fig. 4. *Deutzia Lemoinei* . . . . . II M.
Fig. 5. *D. rosea campanulata* . . . . . I M.
Fig. 6. *D. parviflora ovatifolia* . . . . . I M.

POLYPLOIDY IN THE BETULACEAE

ROBERT H. WOODWORTH

The family Betulaceae contains six genera with more than one hundred species in the temperate and colder regions of the northern hemisphere. Hutchinson (1926) considers the Betulaceae to consist of but two genera, *Betula* and *Alnus*. He places the other four genera, *Carpinus*, *Ostrya*, *Ostryopsis*, and *Corylus* in a new family, the Corylaceae. Over sixty species of these six genera are growing in the Arnold Arboretum, each genus being well represented.

Betula is the best known and the largest genus containing some forty species which grow exclusively in the northern regions. From their circumpolar range they radiate out into Europe, Asia and North America in numbers of parallel forms which fall into somewhat definite geographic entities. They are baffling in their variability and accordingly very difficult to classify. Even though there were four times as many extinct species of *Betula* as there are existing species, the genus came through the glacial periods remarkably well as compared with most genera.

The species and varieties of *Betula* have interesting chromosome numbers. Many have fourteen pairs, four have twenty-eight pairs, two have thirty-five pairs, and three have forty-two pairs of chromosomes. About thirty of the forty known species are growing in the Arnold Arboretum. The specific names used are those found in Rehder's Manual (1927).

The existing species apparently form natural hybrids readily, since fifteen crosses have already been described by taxonomists. Four natural hybrids between species of different chromosome numbers have proved interesting from the cytological standpoint (Woodworth, 1929–1930). *Betula Jackii* is the result of a natural cross between *B. lenta* with fourteen gametic chromosomes and *B. pumila* with twenty-eight gametic chromosomes. Helms and Jorgensen (1925) report a similar European hybrid which is readily formed in nature from *B. verrucosa* with fourteen gametic chromosomes and *B. pubescens* with twenty-eight gametic chromosomes.

In both of the above hybrids there are fourteen pairs and fourteen univalent chromosomes at the metaphase of the reduction division.

B. Sandbergi was discovered in the tamarack swamps of southern Minnesota. Since then it has been found that true *B. pumila* does not occur west of New York State and that the plants which had been called *B. pumila* are really F_2 segregates of *B. Sandbergi* (Rosendahl, 1928). *B. papyrifera* with thirty-five gametic chromosomes and *B. pumila* var. *glandulifera* with twenty-eight gametic chromosomes are the parents of *B. Sandbergi* which has sixty-three chromosomes in the sporophytic tissue. The reduction division usually shows twenty-eight pairs and seven single chromosomes some of which may pair among themselves.

B. Purpusii from the taxonomic evidence is clearly a hybrid between *B. lutea* and *B. pumila* var. *glandulifera*. The former parent has forty-two pairs of chromosomes and the latter parent has twenty-eight. The cytology of the hybrid shows about twenty-eight pairs of chromosomes at the metaphase of the reduction division and about fourteen single chromosomes distributed all along the spindle. The metaphase plates of the sporophytic cells have seventy chromosomes. This plant also grows in the tamarack swamps of Minnesota.

The polymorphism of *B. papyrifera* and its varieties is well known to the systematist. *B. papyrifera* and its variety *kenaica* both have thirty-five pairs of chromosomes. *B. papyrifera* var. *cordifolia* and *B. papyrifera* var. *subcordata* both have twenty-eight pairs of chromosomes. *B. papyrifera* var. *occidentalis* has forty-two pairs of chromosomes.

B. japonica has fourteen pairs of chromosomes. *B. japonica* var. *mandshurica* has at the reduction division fourteen pairs and twenty-eight single chromosomes which behave abnormally. This variety appears to be a natural hybrid between *B. japonica* and some species with forty-two pairs of chromosomes. *B. grossa* grows in the same regions as *B. japonica* and its variety, and has forty-two pairs of chromosomes.

BETULA

Section	Species	Chromosome Number (pairs)	Native Habitat
Eubetula			
Subsection			
Costatae	B. nigra	14	E. U. S.
	B. utilis var. Prattii	14	W. China
	B. Schmidtii	14	N. E. Asia
	B. lenta	14	E. U. S.
	B. lutea	42	E. N. Am.
	B. grossa	42	Japan

Nanae	B. pumila	28	N. E. N. Am.
	B. pumila var. glandulifera	28	N. E. N. Am.
Albae	B. populifolia	14	E. N. Am.
	B. coerulea-grandis	14	N. E. N. Am.
	B. fontinalis var. Piperi	14	N. W. U. S.
	B. pendula	14	S. Eurasia
	B. japonica	14	N. E. Asia & Japan
	B. pubescens	28	N. Eurasia
	B. papyrifera var. cordifolia	28	N. E. N. Am.
	B. papyrifera var. subcordata	28	W. N. Am.
	B. papyrifera	35	N. N. Am.
	B. papyrifera var. kenaica	35	Alaska
	B. papyrifera var. occidentalis	42	W. N. Am.
	B. davurica	about 45	N. E. Asia & Japan
Betulaster Subsection Acuminatae	B. Maximowicziana	14	Japan

Natural Hybrids	Sporophytic & Parental Chromosome Numbers	Native Habitat
B. coerulea (coerulea-grandis × populifolia)	28 (14 + 14)	N. E. N. Am.
B. Jackii (lenta × pumila)	42 (14 + 28)	Mass.
B. verrucosa × pubescens	42 (14 + 28)	N. Europe
B. Sandbergi (pumila var. glandulifera × papyrifera)	63 (28 + 35)	N. U. S.
B. Purpusii (pumila var. glandulifera × lutea)	70 (28 + 42)	N. U. S.
B. japonica var. mandshurica (japonica ×?)	56 (14 + 42)	N. E. Asia

Alnus consists of about thirty species. It is the only member of the family that extends its range into the southern hemisphere and here only in the highlands of the Andes as far south as Peru. The Alders differ from the Birches mainly in their persistent and woody seed bearing cones. Some twelve species are growing in the Arnold Arboretum. The following species have fourteen pairs of chromosomes: *A. incana*, *A. crispa* var. *mollis*, *A. maritima;* while *A. japonica*, *A. Spaethii* and *A. glutinosa* all have twenty-eight pairs of chromosomes. The New England *A. rugosa* is something of a puzzle cytologically. Some of the plants have extremely irregular reduction divisions which strongly suggest a hybrid origin (Woodworth, 1929). Material from all the other species was collected at the same time and treated in exactly the same manner. That the abnormalities were not caused by the fixing fluid or any external agent is clearly shown by the presence

of dwarf pollen grains and almost complete sterility of the contents of the anthers. When the divisions of the spore mother cells of *A. rugosa* are at all normal they have fourteen pairs of chromosomes. At other times it seems that some of the chromosomes have fragmented or that the other parent had about twenty-eight chromosomes. Although cytological material of *A. rugosa* from the southeastern United States has not yet been available for study, some of the mature catkins have been procured from Virginia and these have almost perfect pollen. This suggests that the polymorphism and cytological irregularities of the New England *A. rugosa* is probably due to the formation of natural hybrids between *A. incana* and *A. rugosa* where the two species grow together. Experiments are now being carried out along this line in an attempt to produce hybrid *A. rugosa*.

A. Spaethii has been reported as a hybrid between *A. subcordata* and *A. japonica*. *A. Spaethii* has regular meioses with twenty-eight pairs of chromosomes. *A. japonica* growing in the Arnold Arboretum also has twenty-eight pairs. Catkins of *A. subcordata* have not been available to me for study but Wetzel (1929) reports fourteen pairs of chromosomes for this species and also for *A. japonica*. If *A. Spaethii* is a hybrid its parents must have been either fourteen chromosome or twenty-eight chromosome individuals. If they had fourteen chromosomes there is no homology between any of the members of the chromosome sets, and if the parents had twenty-eight chromosomes there is complete homology between the chromosome sets. I believe that the hybrid nature of *A. Spaethii* is open to question.

There are fifteen species of *Corylus*. The Hazels are well known as ornamental trees and shrubs but perhaps better for their edible nuts (filberts and hazelnuts). The eleven species, five varieties and one hybrid growing in the Arnold Arboretum all have fourteen pairs of chromosomes. They are: *C. americana*, *C. americana* × *pontica*, *C. Avellana*, *C. Avellana* var. *pendula*, *C. Avellana* var. *pontica*, *C. colurna*, *C. cornuta*, *C. heterophylla*, *C. heterophylla* var. *sutchuenensis*, *C. maxima*, *C. maxima* var. *purpurea*, *C. Sieboldiana*, *C. Sieboldiana* var. *mandshurica*, *C. tibetica*, *C. spinescens*, *C. Vilmorinii*, *C. no. 9 of Vollertsen*. Wetzel (1929) reports the haploid number to be eleven in *C. Avellana*, *C. maxima* and *C. mandshurica*.

Species	Chromosome Number (pairs)	Native Habitat
Alnus incana	14	N. E. N. Am., Eur.
A. rugosa	14	E. N. Am.
A. crispa var. mollis	14	N. E. N. Am.

Species	Chromosome Number (pairs)	Native Habitat
A. maritima	14	E. N. Am.
A. japonica	14[1], 28	Japan, N. E. Asia
A. Spaethii	28	unknown
A. glutinosa	28	Eurasia, N. Afr.
A. subcordata	14[1]	Asia
Carpinus caroliniana	8	E. N. Am.
C. laxiflora	8	China
C. orientalis	8	S. E. Eur., Asia Minor
C. Turczaninovii	8	China, Korea
C. japonica	8	Japan
C. cordata	8	Asia
C. betulus	8	Eurasia
C. betulus var. fastigiata	32	
Ostrya virginiana	8	E. N. Am.
O. virginiana var. glandulosa	8	N. E. N. Am.
O. carpinifolia	8	S. Eur., Asia Minor
O. japonica	8	Asia
Ostryopsis Davidiana	8	China
Corylus (all species)	14	N. Am., Eur., Asia

[1] Wetzel, 1929.

There are about twenty species of *Carpinus*. The Hornbeams are known for their handsome foliage and their extremely hard and tough wood. It is noteworthy that the species have eight pairs of chromosomes which is in marked contrast to the species of the three genera treated above, which have fourteen as the fundamental number. *C. betulus* var. *fastigiata* deserves special mention since it has thirty-two pairs of chromosomes while *C. betulus*, *C. caroliniana*, *C. laxiflora*, *C. Turczaninovii*, *C. orientalis*, *C. japonica*, *C. cordata* all have eight pairs.

There are seven species of *Ostrya*, the Hop-hornbeam. Mature plants of *O. virginiana*, *O. virginiana* var. *glandulosa*, *O. carpinifolia*, *O. japonica* are growing in the arboretum. They all, like *Carpinus*, have eight pairs of chromosomes.

Ostryopsis has but two species. One, *O. Davidiana*, is growing in the Arnold Arboretum. It has eight pairs of chromosomes.

The chromosomes at the reduction division in the Betulaceae are almost spherical and small. The species of *Betula*, *Alnus*, *Carpinus*, *Ostrya*, and *Ostryopsis* have chromosomes which measure approximately one micron in diameter. The notable exceptions to this measurement are those species of *Betula* which have large numbers of chromosomes. The three plants with forty-two gametic chromosomes show these bodies to have a diameter of .6 of one micron, while those species with the intermediate chromosome numbers show, in general, an intermediate chromosome diameter. In the above genera the size of the pollen mother cells

and the pollen grains increases as the chromosome number increases.

The chromosomes of the various species and varieties of *Corylus* are very small. They average approximately 0.5 of one micron in diameter. Compared with diploid species of the other genera they are half size. Nevertheless the pollen mother cells and the pollen grains are as large as those of any species in the family.

It has frequently been found that the species of certain subgenera or subsections will readily hybridize among themselves but not with the species of other subgenera or subsections, while in other groups there is free crossing between diverse species or even between genera. In recently suggested definitions of a species free intercrossing and high interfertility among the individuals of the group and absence of free intercrossing and low fertility or complete sterility in interspecific hybrids are considered important for the genetic bearing on the species concept (Muntzing, Tedin and Turesson, 1931; Babcock, 1931; Sax, 1931). In *Betula* the data above show that *B. pumila*, representing the dwarf Birches, readily hybridizes with species of both other subsections. Furthermore, it has recently been found that the plants from Michigan, Wisconsin, Minnesota, and Indiana which have long been called *B. pumila* are in reality F_2 segregates of $\times$ *B. Sandbergi* and that true *B. pumila* does not occur west of New York State (Rosendahl, 1928). Since *B. lenta* and *B. pumila* var. *glandulifera* are quite distinct species the hybrid *B. Sandbergi* is an exception to the genetic part of the specific concept noted just above. Experiments discussed below show the Betula species to hybridize readily.

EXPERIMENTAL HYBRIDS

The following experiments in crossing birch species have proved successful to the extent that embryos were formed. In each case twelve seeds were cut open and examined. The seeds of a great many more crosses than these have been planted but only in those listed here have embryos been seen. The gametophytic chromosome number of each parent is given.

B. pendula (14) produced seeds with embryos when crossed with: *B. coerulea-grandis* (14), *B. pumila* (28), *B. papyrifera* var. *cordifolia* (28), *B. grossa* (42).

B. Maximowicziana (14) crossed with *B. lutea* (42) and *B. davurica* (about 45).

B. pumila (28) crossed with *B. lenta* (14), *B. nigra* (14), *B. japonica* (14), *B. Maximowicziana* (14), and *B. papyrifera* var. *cordifolia* (28).

B. papyrifera var. *cordifolia* (28) crossed with *B. pendula* (14), *B. pumila* (28), *B. papyrifera* var. *kenaica* (35), *B. lutea* (42), and *B. papyrifera* var. *occidentalis* (42).

B. papyrifera var. *kenaica* (35) crossed with *B. papyrifera* var. *occidentalis* (42).

B. lutea (42) crossed with *B. lenta* (14), *B. coerulea-grandis* (14), *B. pumila* (28), *B. grossa* (42), and *B. papyrifera* var. *occidentalis* (42).

B. papyrifera var. *occidentalis* (42) crossed with *B. lenta* (14), *B. pendula* (14), *B. pumila* (28), *B. papyrifera* (35) and *B. papyrifera* var. *kenaica* (35).

B. davurica (about 45) crossed with *B. pendula* (14), *B. Maximowicziana* (14), *B. papyrifera* (35), *B. lutea* (42), and *B. japonica* var. *mandshurica* (42).

If all of these crosses which are known to have formed seeds with embryos should produce viable plants, hybrids with the following sporophytic chromosome numbers would be formed: one diploid (28), seven triploids (42), nine tetraploids (56), four pentaploids (70), one octoploid (84), and these dysploids; one 49, three 59's, one 63, one 77, one 80, and two 87's.

Since these seeds have not yet germinated it may be a little early to anticipate results, but it does seem as though the species of *Betula* are highly interfertile.

DISCUSSION

Species formation is probably due to changes in chromosome structure and chromosome number. Some genera consist of species all of which have the same chromosome number. Species formation in such groups might be attributed to gene mutations and other structural changes within the individual chromosomes aided perhaps by hybrids between varieties. Other genera consist of species which have different chromosome numbers. Species formation in these groups might be due not only to the causes mentioned above but also to the duplication of chromosomes or chromosome sets and to the combination of chromosome sets from different species.

Recent points of view hold that mutations are the basic cause of variation and evolution and that evolution is speeded up and aided by first varietal and later species hybridization (Wright, 1931 and others).

Many interesting polyploid series have been investigated. Considerable evidence supports the view that plants with the higher chromosome numbers have originated from those species with the smaller chromosome complement. A useful distinction has been

made amongst polyploids (Kihara & Ono, 1926) according as their gametic complements are built up by the reduplication of similar series (autopolyploidy), that is, by the doubling of the chromosome number in a theoretically pure line, or by the combination of dissimilar series (allopolyploidy), that is, by doubling in a hybrid. There is not complete agreement as to which of these types of polyploid formation is the more frequent in nature. Jorgensen (1928) considers that hybridization has played a much greater role in the improvement of our cultivated plants than it has in species formation; that species hybridization occurs but rarely in nature; and that tetraploidy induced in the sparse species hybrids found in nature is very rare in comparison with the tetraploidy found in the huge numbers of pure species. Darlington (1927 and 1928) on the other hand concludes that polyploids have often arisen as the result of hybridization between diploid species and that most normally seed producing polyploids occurring in nature fall in the allopolyploid group.

Species of *Ostrya*, *Ostryopsis* and *Carpinus* all have eight as the basic chromosome number while species of *Betula*, *Alnus* and *Corylus* have the basic number of fourteen. Hutchinson (1926) has placed *Betula* and *Alnus* in the Betulaceae and has proposed another family, the Corylaceae, for *Corylus*, *Carpinus*, *Ostrya* and *Ostryopsis*. From the standpoint of chromosome number *Corylus* should go in with *Betula* and *Alnus*. Furthermore, *Corylus* species form their staminate catkins and mature their pollen in the fall as do the species of *Betula* and *Alnus* (except *A. maritima*) while the members of the other genera form and mature their pollen just previous to its shedding in the spring. If the family is to be split into two families a more natural grouping from the developmental and cytological evidence would place *Corylus* in with *Betula* and *Alnus*.

The basic chromosome number in this family is apparently seven, although no member has yet been found to have seven pairs of chromosomes. The eight chromosome genera may have originated from an original seven chromosome strain by the duplication of one chromosome. The fourteen chromosome genera would then have come about by a duplication of the original set of seven chromosomes. The meiotic conditions in *Corylus* may be of significance here. Wetzel (1929) reports eleven pairs of chromosomes in *C. Avellana*, *C. maxima* and *C. mandshurica*. During the reduction division in all species listed above there is an affinity between some of the gemini to the extent that usually two and sometimes three pairs of bivalents fuse to form tetrasomes, thus

often causing the haploid number to be less than fourteen (Woodworth, 1929). If this be a normal process it may indicate an affinity of homologous chromosome pairs which in turn suggests a doubling, if not of a whole chromosome set, at least of certain chromosomes. However, Yarnell (1929) has shown that we can not be too dogmatic about the idea that only homologous chromosomes pair. In an artificially produced triploid *Fragaria* he has found unmistakable pairing between non-homologous chromosomes. This also happens in *Betula Sandbergi*.

Species formation in the genus *Corylus*, since all species have fourteen chromosome pairs, might be attributed to gene mutations and other structural changes within the individual chromosomes aided perhaps by hybrids between varieties, although it has recently been suggested that gene mutations have little influence in species formation (Anderson, 1928).

Species of *Alnus* seem to be well defined, with the exception of the New England material of *A. incana* and *A. rugosa*. The existence of much intergrading material makes for obscurity in specific lines. Much of the *A. rugosa* material has very abnormal meioses in both microgametophyte and macrogametophyte and the abundance of viable seed has been found to develop apogamously and to be polyembryonic (Woodworth, 1930). There is then here a correlation between polymorphism and reproductive irregularities. Some specimens of *A. japonica* have been reported as having fourteen pairs of chromosomes while others have twenty-eight pairs. Since the plants are taxonomically *A. japonica* there is no doubt that there has been a duplication of the chromosome set (autopolyploidy).

Carpinus betulus has eight pairs of chromosomes, while its variety *fastigiata* has thirty-two pairs. This variety obviously belongs to *C. betulus* because it differs only in its narrow pyramidal habit. The octoploid chromosome number probably originated in a four fold reduplication of the eight pairs of chromosomes (autopolyploid).

It has been mentioned above that *Betula* species are very difficult taxonomically. This is due to many intergrading forms. Fernald (1902) has shown that it is possible to trace by a series of specimens a direct connection between dwarf *B. nana*, through variants of many other species, to the tall *B. alba*. He notes that since it is obviously impracticable to regard all these forms as one species, it seems wise to recognize the more marked centers of variation as species which are admitted to pass by exceptional tendencies to other forms ordinarily distinguished by marked characteristics.